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NEW SPECIES AND VARIETIES OF FRESHWATER ALGAE FROM CHINA.*

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During the years 1930–1932 through the generous cooperation of scientific men and friends in China and America, the writer received a rather continuous supply of Chinese freshwater algae collected at different localities and seasons. Among the algae of the eight hundred collections examined were four new species and two new varieties. The following is a description of these forms, the time and place of collection, and notes on their habitats. Both Latin and English diagnoses are given:

Scytonema crispum (Ag.) Born. var. **minus** var. nov.
(Plate I, Fig. 4.)

Strato caespitoso, intricato, viridi-fuscescente vel olivaceo; filis 10–15μ crassis, 0.51–1 centim. longis, crispis; pseudoramis conformibus; vaginis firmis, membranaceis, hyalinis; trichomatibus 7–10μ crassis, cellulis 3.0–4.0μ longioribus; heterocystis 8–10μ latis, 6–10μ longioribus; depressis vel quadratis, modo numerosis.

Plant mass caespitose, entangled, woolly, green to brown; filaments 10–15μ in diameter, about 0.5–1 cm. in length, curled, branched; sheath firm, membranaceous, colorless; trichomes 7–10μ in diameter, cells 3.0–4.0μ in length; heterocysts 8–10 $\times$ 6–10μ, depressed or quadrate, numerous.

Similar to the species proper but distinguished by smaller dimensions of the trichomes.

"On rocks with dripping water" (Wang), Nanking, China, April 16, 1930. Type, Mr. Y. C. Wang's collection, No. 76 and 77, in the Herbarium of National Tsing Hua University, Peiping, China.

*Papers from the Department of Botany, the Ohio State University, No. 304.

Oedogonium sinense sp. nov.
(Plate I, Fig. 1.)

Oedogonium dioicum nannandrium, idioandrosporum (?); oogoniis singulis, ovoideis vel globoso-ellipsoideis, poro supramediano apertis; oosporis subglobosis vel oviformis, oogonia fere complentibus, laevi, fuscescentibus; cellulis vegetativis leviter capitellatis; nannandribus in cellulis suffultoriis curvatis; cellulis vegetativis 29–44μ latis, 128–170μ longioribus; cellulis suffultoriis 64μ latis, 182μ longioribus; stipite nannandribus 23μ latis, 82μ longioribus; antheridio exteriore, 2-cellulari, 12–14μ latis, 15–18μ longioribus.

Dioecious, nannandrous, idioandrosporous (?); oogonium 1, ovoid or globose-ellipsoid, poriferous, pore supramedian; oospore subspherical or oviform, almost filling the oogonium; spore wall smooth, yellow-brown; vegetative cells slightly or not capitellate; dwarf male curved, on suffultory cell; vegetative cells 29–44 × 128–170μ; suffultory cell 64 × 182μ; dwarf male stipe 23 × 82μ; antheridium exterior, 2-celled, 12–14 × 15–18μ.

Distinguished from *Oedogonium nebraskense* Ohashi by its larger dimensions and smooth oospore walls.

In association with other algae in Hsuan Wu Lake, Nanking, China, April 20, 1930. Type, Mr. Y. C. Wang's collection, No. 125, in the Herbarium of National Tsing Hua University, Peiping, China.

Mougeotia sinensis sp. nov.
(Plate I, Figs. 2–3.)

Cellulis vegetativis 15–22μ latis, 100–132μ longioribus; cellulis conjugatio leviter geniculatis; sporangia inter 2 cellulis sitis; chromatophoro elongato cum pyrenoidibus 4–6; zygosporis ovoideis vel globosis, 25–31μ latis, 29–31μ longioribus, formatis canali copulationis; mesosporio angulari-reticulato, fuscescentibus.

Vegetative cells 15–22 × 100–132μ; conjugating cells slightly geniculate; sporangia adjoined by 2 cells; chromatophore with 4–6 pyrenoids in a single row; zygospores ovoid to globose, 25–31 × 29–31μ, formed in the conjugating tube; median walls angularly reticulate, yellow-brown.

Among the species of Mougeotia in which the sporangia are joined by two cells, *Mougeotia sinensis* is the only one with angularly reticulate zygospores.

Intermixed with *Zygnema synadelphum* Skuja and other algae, Tinghai, China, Spring, 1930. Type, Prof. C. C. Wang's collection, No. 501, in the Herbarium of National Central University, Nanking, China.

Spirogyra wangi sp. nov.
(Plate I, Figs. 7–8.)

Cellulis vegetativis 30–32μ latis, 150–350μ longioribus, dissepimenta replicata; 2–3 chromatophoris anfractibus 1.5–4.5; cellulis fructiferis ad 72μ inflatis; zygosporis ellipsoideis, 60–64μ latis, 112–124μ longioribus; mesosporio laevi.

Vegetative cells 30–32 × 150–350μ, with replicate end walls; 2–3 chromatophores making 1.5–4.5 turns; fertile cells inflated to 72μ; zygospores ellipsoid, 60–64 × 112–124μ; median wall smooth.

Characterized by the inflated fertile cells, larger zygospores and number of chromatophores.

Growing with other filamentous algae, Hangchow, China, Spring, 1930. Type, Prof. C. C. Wang's collection, No. 40, in the Herbarium of National Central University, Nanking, China.

Spirogyra sinensis sp. nov.
(Plate I, Figs. 5–6.)

Cellulis vegetativis 22–24μ latis, 115–136μ longioribus; dissepimentis planis; 2–4 chromatophoris, anfractibus 2.5–4.5; cellulis fructiferis medio valde inflatis fere 50μ; zygosporis lenticularis, diam. 38–45μ; mesosporio laevi.

Vegetative cells 22–24 × 115–136μ; end walls plane; 2–4 chromatophores making 2.5–4.5 turns; fertile cells inflated toward the middle to about 50μ; zygospores lenticular, 38–45μ in diameter; median walls smooth.

This species is distinguished from *Spirogyra pellucida* (Hass.) Kutz. and the variety *minor* Tiffany by the smaller vegetative cells and fewer number of chromatophores in some of the cells, and by the very thick zygospore wall.

Hsuan Wu Lake, Nanking, China, April 20, 1930. Type, Mr. Y. C. Wang's collection, No. 125, in the Herbarium of National Tsing Hua University, Peiping, China.

Zygnema collinsianum Transeau var. **ornatum** var. nov.
(Plate I, Figs. 9–10.)

Cellulis vegetativis 28–32μ latis, 34–96μ longioribus; cellulis fructiferis uno latere (in quo conjugatio sequiter) fere inflatis; zygosporis globosis vel ovoideis, 28–32μ latis, 32–35μ longioribus, maturitate caeruleis, mesosporio scrobiculis magnis.

Vegetative cells 28–32 × 34–96μ; fertile cells inflated slightly on the conjugating side; zygospores, in one of the gametangia, globose to ovoid, 28–32 × 32–35μ, median walls pitted, blue; pits of median walls about 6μ in diameter.

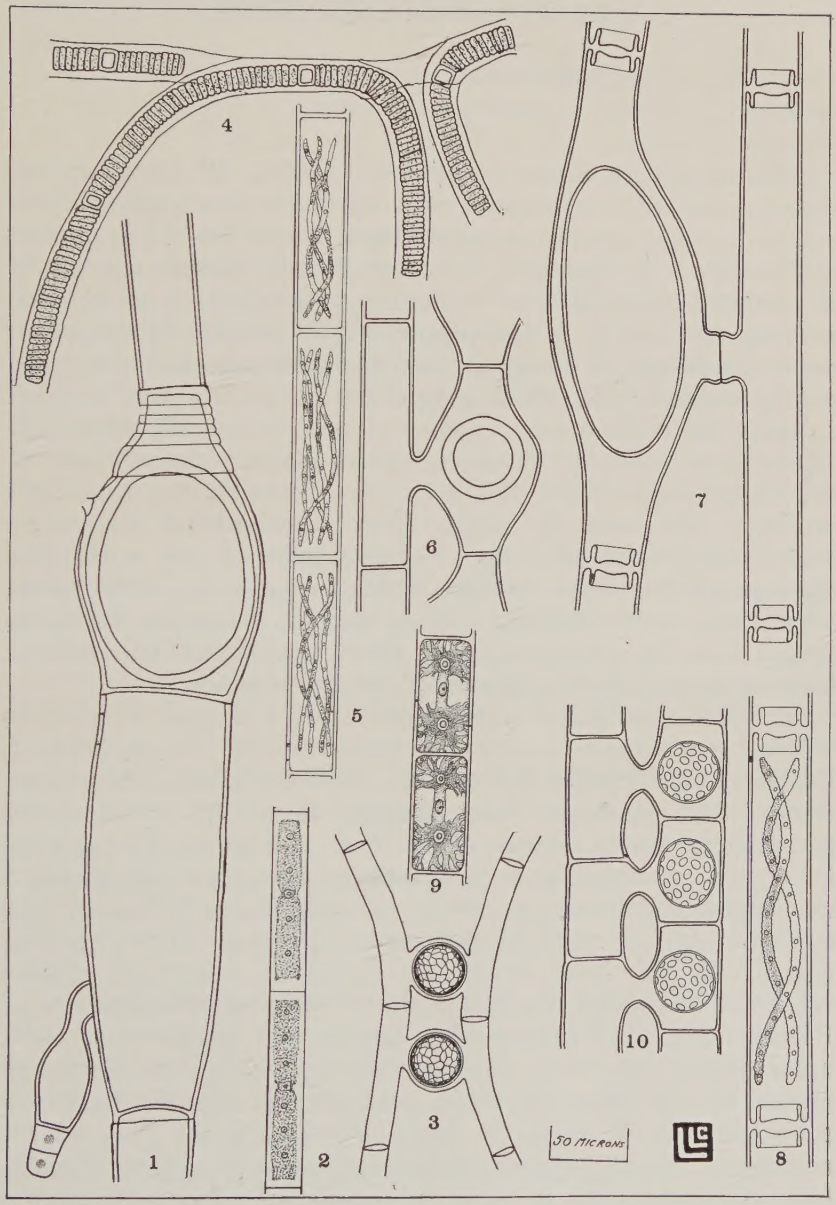
Distinguished from the type by the larger dimensions of the vegetative cells; otherwise similar.

"Floating in mass in a pool, and in the fields just in front of Nanputo Temple" (Tseng), Amoy, China, April 16, 1931. Type, Mr. C. K. Tseng's collections FB Nos. 1 and 2, in the Herbarium of the University of Amoy, Amoy, China. Subsequently found in U. S. A. (Alabama, Mississippi, and Oklahoma).

The writer wishes to thank Professors Lewis H. Tiffany and Edgar N. Transeau, of the Department of Botany, the Ohio State University, for their helpful suggestions, kind criticisms, and the checking of determinations. For the generous supply of their collections of algae from different parts of China, the writer is indebted to Professor Josephine E. Tilden, University of Minnesota; Mr. Y. C. Wang, National Tsing Hua University; Professor C. C. Wang, National Central University; Professor H. H. Chung and Mr. C. K. Tseng, University of Amoy; and Professor J. W. Dyson, Soochow University.

EXPLANATION OF PLATE.

Fig. 1. *Oedogonium sinense*, sp. nov.
Figs. 2–3. *Mougeotia sinensis* sp. nov.
Fig. 4. *Scytonema crispum* (Ag.) Born. var. *minus* var. nov.
Figs. 5–6. *Spirogyra sinensis* sp. nov.
Figs. 7–8. *Spirogyra wangi* sp. nov.
Figs. 9–10. *Zygnema collinsianum* Transeau var. *ornatum* var. nov.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THE GENUS ZYGOGONIUM.

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Ohio State University.

Taking *Zygogonium ericetorum* (Kütz.) de Bary as the type species of the genus there are three outstanding characteristics that clearly separate these forms from the species of *Zygnema*. In the first place the chromatophores are a pair of rounded plate-like, or irregular polsterform bodies, each with a central more or less prominent pyrenoid. When grown under conditions of poor nutrition the chromatophores may be poorly defined, and when gorged with starch grains and oil droplets the outline may become almost completely obscured. These facts account for the many conflicting descriptions of the chromatophores in the literature discussed by West and Starkey, 1915, and by Skuja, 1932. Certainly in the many collections I have seen from various parts of the world, the chromatophores were never stellate or globose with radial projections as in *Zygnema*. Most authors following Palla are agreed that the chromatophores afford one of the fundamental bases of separating the genera of the *Zygnemales*.

In the second place, a sporangium wall is formed which cuts off the gametangia before the formation of the spore wall. De Bary, 1858, and Hodgetts, 1918, have described the conjugation of this species as proceeding by formation of secondary gametangia which subsequently fuse and form the zygote. It is quite probable that such fusions do take place. However, a not improbable interpretation of their figures and observations is that these are arrested and encysted stages in conjugation, comparable to those sometimes found in other Zygnemales subjected to sudden changes in water content and temperature. Furthermore, *Z. ericetorum* has an unusual tendency to form aplanospores, akinetes, azygospores, or "cysts," as has been remarked by West, Fritsch, and many others. It seems probable that W. & G. S. West (1894) gave the first correct account of the conjugation of *Z. ericetorum* when growing under favorable conditions in their description of "Zygnema pachydermum." In material collected near Longwood, Florida, in a drainage ditch I found not only the encysted stages described

by de Bary and by Hodgetts, but also conjugation without the formation of secondary gametangia, as shown on the accompanying figures.

The third characteristic of *Zygogonium* is that there is a cytoplasmic residue left in the gametangia, just as in the genus Mougeotia. This is very marked in *Z. ericetorum*, and also takes place when aplanospores are formed from vegetative cells. In *Zygnema* such residues have not been observed either in conjugation or in aplanospore formation.

Skuja (1932) has shown that *Pleurodiscus* Lagerheim is merely an extreme form of *Z. ericetorum* in which the two chromatophores are disc or saucer-shaped. West has examined the original specimens of *Zygogonium didymium* Rabenh. (Alg. Exsic. No. 182) and found them to be identical with *Z. ericetorum*.

As the genus *Zygogonium* is here defined there is no basis for separating *Pyxispora* W. & G. S. West (1897). This genus was largely postulated on the basis of a prominent equatorial suture in the sporangium wall. The Florida material of *Z. ericetorum* also shows a median suture on some of the sporangia and the spores are set free by the splitting of the sporangium wall along this line.

The plant rather inadequately described by Schmidle in 1897 as "Zygnema Heydrichii" should evidently be classified in this genus. This collection showed only lateral conjugation with the zygote formed in the greatly enlarged tube, which is cut off from the gametangia by cross walls and thus forms a distinct sporangium. Schmidle's figures suggest that this sporangium also splits by a median suture.

Recently Iyengar has described a species from India that is distinguished by the peculiar and regularly lateral position of the aplanospores.

Finally two species described as Zygnemas which have been found producing only aplanospores seem to be better classified in this genus.

Following are the diagnoses of the genus and six species.

ZYGOGONIUM (Kütz.) de Bary.

Filamentous algae with cylindrical cells containing two axillary disc-, or polsterform chromatophores with rounded, or irregular, margins, each with a central pyrenoid; connected by a cytoplasmic isthmus to which the nucleus is attached laterally. Filaments usually unbranched,

but sometimes with lateral branches of several, or many, cells. Cell walls thin, or lamellate and greatly thickened, often yellowish or brownish in color, cell sap sometimes purple.

Reproduction by akinetes, aplanospores and by zygotes. Akinetes formed by pronounced thickening of cell walls. Aplanospores formed by the contraction of a part of the cell contents and the formation of a new globose or ovoid spore wall within the vegetative cell wall, leaving a more or less conspicuous mass of cytoplasmic residue outside the spore wall. Zygotes produced by the scalariform, or lateral conjugation of isogamous gametes, which are formed from only a part of the cell contents. Encysted gametes have been interpreted as secondary gametangia, but are not necessarily formed in aquatic habitats. Zygotes enclosed in a definite sporangium, which dehisces by an equatorial suture. Spore wall smooth or scrobiculate.

1. **Zygogonium ericetorum** Kützing, 1843.

(Plate I, Figs. 1–12; Plate II, Figs. 33–35.)

Phycologia generalis, p. 446; A. de Bary, Untersuchungen uber die Familie der Conjugaten. 1885; West and Starkey, Cytology and Life History of *Zygnema ericetorum*, New Phytologist, 14: 194. 1915; Hodgetts, Conj. of *Zygogonium ericetorum*, New Phytologist, 17: 238, 1918; Skuja, Le genre *Pleurodiscus*, Rev. algolog. 6: 137. Includes *Z. didymum* Rab., *Z. agardhii* Rab. and *Pleurodiscus purpureus* (Wolle) Lagerheim and *Zygnema pachydermum* W. & G. S. West.

A highly variable terrestrial or submerged form with unbranched or branched filaments. Vegetative cells vary from 12–33μ in diameter and from 10 to 100μ in length. Chromatophores two, axillary, disc- or polsterform or indefinite, each with a central pyrenoid, zygospores develop in a definite sporangium, formed by the conjugating tube and cut off from the adjoining gametangia. Zygospores thick walled, smooth, ovoid or ellipsoid, 15–26μ × 20–36μ. Aplanospores globose or ovoid, occupying only a part of the cell, 15–20μ × 15–40μ, wall smooth.

In terrestrial forms the cell sap is frequently purple, the cells somewhat smaller, and the walls thick, lamellate, colored yellow or brown. Widely distributed in bogs, acid pools, and on wet acid soils. Reported from all of the continents. In America known to occur throughout the coastal plain from New Brunswick to Mississippi and in Ohio, Michigan and Southern Ontario.

2. **Zygogonium mirabile** (W. & G. S. West) Comb. nov.

(Plate II, Figs. 18–20.)

Pyxispora mirabilis W. & G. S. West, Welwitsch's African Freshwater Algae, Jour. Bot. 35: 1897; *Zygnema mirabile* (W. & G. S. W.) Czurda, 1932.

Vegetative cells 12–13.5μ × 18–50μ with two rather indistinct chromatophores, each with a central pyrenoid. Only a part of the contents of the vegetative cells enters into the formation of the

gametes. Zygospores formed in the enlarged conjugating tubes, which are walled off from the original cells. Sporangium ovoid with prominent equatorial suture. Spores filling the sporangium smooth walled, but possibly not mature in the one known collection, 13.5–17μ × 19–32μ.

Collected by Welwitsch, Huilla, Portuguese West Africa, April, 1860.

3. **Zygogonium heydrichii** (Schmidle) Comb. nov.

(Plate II, Figs. 21–25.)

Zygnema heydrichii Schmidle, Zur Entwickelung einiger Zygnema und Calothrix. Flora 83: 167. Pl. V, Figs. 5–7, 10–11. 1897.

Vegetative cells 20μ × 25–66μ, with two chromatophores, not stellate, in each cell. Conjugation lateral by tubes arising from adjoining cells, forming a sporangium cut off from the original cells. Spores globose, ovoid or heart-shaped, 24–28μ × 32μ, median wall yellow, scrobiculate.

Collected by Lauterbach at Sidney, Australia.

4. **Zygogonium capense** (Hodgetts) Comb. nov.

(Plate II, Figs. 26–28.)

Hodgetts, W. J. Some Freshwater Algae from Stellenbosch, Cape of Good Hope. Trans. Roy. Soc. South Africa, 13: 66. 1925. (*Zignema capense.*)

Vegetative cells 16–20μ, 1.3–3 diameters long, conjugation unknown, aplanospores globose formed at the ends of the cells, 19–26μ in diameter, median wall brown, scrobiculate.

Evidently closely related to *Z. heydrichii.* The tendency to form aplanospores at the ends of vegetative cells is also characteristic of many collections of *Z. ericetorum.*

On damp earth, Stellenbosch, South Africa.

5. **Zygogonium hansgirgi** (Schmidle) Comb. nov.

(Plate II, Figs. 29–32.)

Schmidle, W. Ueber einige von Prof. Hansgirg in Ostindien gesammelte Suesswasseralgen. Hedwigia 39: 160. 1900. (*Zignema hansgirgi.*)

Filament short, vegetative cells irregular 8–12μ, 3–5 diameters long, conjugation unknown; aplanospores variable, ovoid, about the same diameter as the cells; median wall brown, with small angular protuberances (verrucose).

Igatpuri, India, 1895.

6. **Zygogonium talguppense** Iyengar, 1932.

(Plate II, Figs. 36–37.)

Iyengar, O.-P. Studies on Indian Zygenemales, Rev. Algologique 6: 263–274. 1932.

Filaments forming a thick felt on soil, increasing in width upwards, often branching below, lower cells of the filament 12–16μ × 30–60μ, the upper 17–20μ × 30–90μ. Aplanospores ("azygospores") developed in a lateral swelling and cut off from the parent-cell by a curved wall, ellipsoid to subglobose 12–26μ × 13–34μ, median wall smooth; zygospores unknown.

On moist soil in a plantation of Areca palms, Talguppa, Mysore, India.

EXPLANATION OF PLATES.

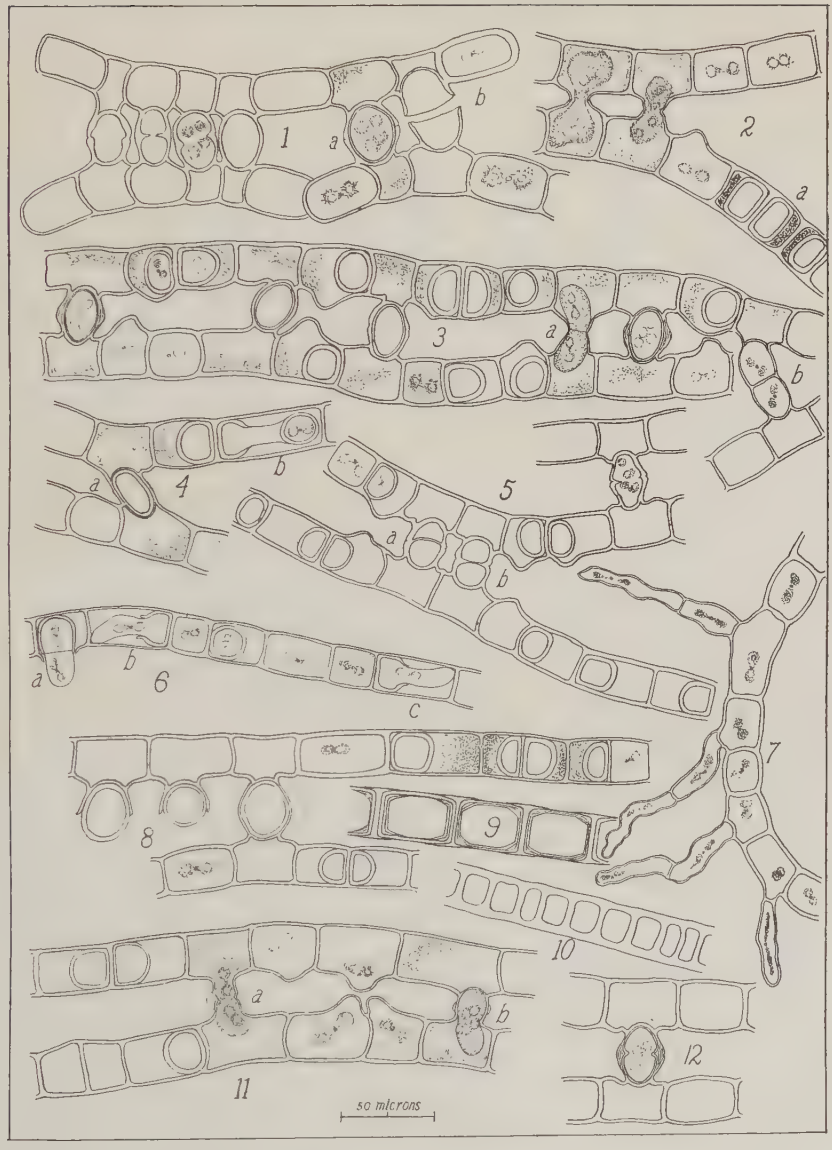
Plate I.

(Figs. 1–12. *Zygogonium ericetorum* from a drainage ditch at Longwood, Florida.)

Fig. 1. Zygospores of various forms: (a) sporangium wall showing equatorial suture; (b) ruptured sporangium from which the spore has escaped.
Fig. 2. Conjugation without formation of secondary gametangia, also aplanospores adjoined by cytoplasmic residue.
Fig. 3. Zygospores and conjugating gametes (a) and encysted gametes at (b).
Fig. 4. Zygospores (a) and at (b) aplanospore that has germinated and formed a secondary aplanospore inside the original vegetative cell.
Fig. 5. Encysted gametes which may perhaps conjugate later.
Fig. 6. Germinating aplanospores.
Fig. 7. Filament showing rhizoidal branches.
Fig. 8. Zygospores, parthenospore and several aplanospores.
Fig. 9. Cells showing lamellate wall and distinct H-pieces formed between the cells.
Fig. 10. Thick-walled short cells.
Fig. 11. Conjugation of gametes with prominent pectic ring at (a), and at (b) sporangium wall formed on one side and not on the other.
Fig. 12. Zygospore.

Plate II.

Figs. 13–15. *Zygogonium ericetorum* (formerly described as *Pleurodiscus purpureus* Lagerheim) after Skuja, 1932.
Fig. 16. *Z. ericetorum*, aplanospores after West & Starkey, 1915.
Fig. 17. *Z. ericetorum*, actively growing cell after Czurda, 1931.
Figs. 18–20. *Zygogonium mirabile* showing sporangia and spores after G. S. West.
Figs. 21–25. *Zygogonium heydrichii* showing lateral conjugation after Schmidle.
Figs. 26–28. *Zygogonium capense* showing aplanospores, after Hodgetts, 1925.
Figs. 29–32. *Zygogonium hansgirgi* showing aplanospores, after Schmidle, 1900.
Figs. 33–35. *Zygogonium ericetorum* from Kwong Tung, China, (McClure Collection). Showing zygospores, aplanospores, and parthenospores. At (34a) partial fusion of three encysted gametes. These specimens were growing on moist soil, and the stages in conjugation are very similar to Hodgett's figures.
Figs. 36–37. *Zygogonium talguppense* from Mysore Province, India, showing aplanospores, after Iyengar.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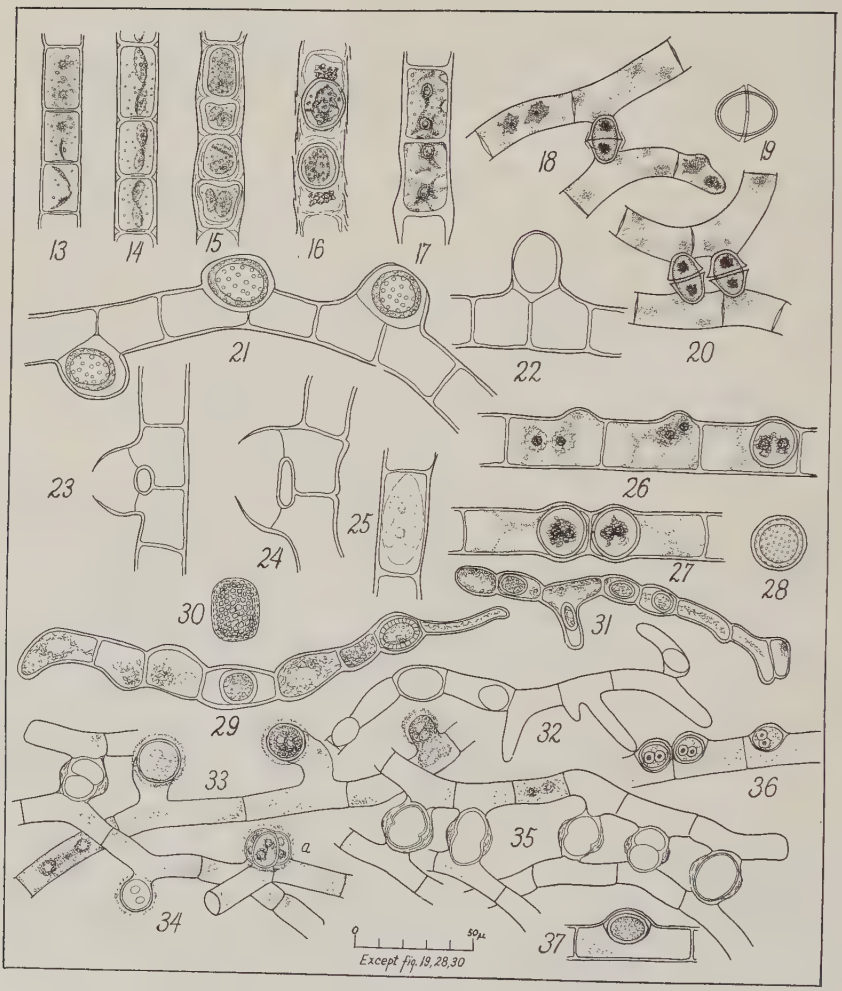
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DISTRIBUTION AND FLOWERING IN WOLFFIA PAPULIFERA.

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It has been supposed for some time that the Pointed Duckweed (*Wolffia papulifera* Thompson) occurred only in the type locality in Missouri. During a taxonomic and anatomical study of the genus *Wolffia* in eastern North America, however, the writer brought to light additional localities where this interesting species has been found.

The following is a list of the stations where the plant is known to have been collected. The writer has examined the material from each station with the exception of those reported by Bravo from near Mexico City, and Bush from Kennett, Missouri, the latter being checked by Thompson.

Locality	*Date*	*Collector*
Kennett, Missouri, U. S. A.	1895	B. F. Bush.
Columbia, Missouri, U. S. A.	1897	C. H. Thompson.
Linn Co., Kansas, U. S. A.	1897	A. S. Hitchcock.
Mexico City, Mexico	1930	H. Bravo.
Latonia, Kentucky, U. S. A.	1931	D. M. Brown.
Jackson Co., Ohio, U. S. A.	1932	R. B. Gordon.
Southern Campeche, Mexico	1932	C. L. Lundell.

During the summers of 1927 and 1928, Saeger collected some material from the type locality in Missouri which bore flowers. The present writer has also found flowers on the material collected by Lundell in Campeche. These two collections are the only ones known to contain plants bearing flowers.

The writer wishes to thank all those who have furnished material for identification and study, the more complete results of which are to be included in a forthcoming paper on the taxonomy and anatomy of the genus.

LITERATURE.

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Saeger, Albert. The Flowering of Lemnaceae. Bull. Torrey Bot. Club, 56: 351–358. 1929.

Thompson, C. H. A Revision of the American Lemnaceae Occurring North of Mexico. Ann. Rept. Mo. Bot. Gard., 9: 21–42. 1898.

SOME EFFECTS OF VARYING AMOUNTS OF NITROGEN ON THE GROWTH OF TULIP POPLAR SEEDLINGS.*

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Ohio State University.

INTRODUCTION.

While many studies have been made on both the more general and the detailed effects of different amounts of available nitrogen on several horticultural and crop plants, few investigators have given much consideration to comparable problems relative to forest tree species. It is known, however, that plants in general under these conditions make somewhat similar responses in leaf color and vegetative organs, but that the more detailed behavior varies widely. The present study began with one year old seedlings of tulip poplar (*Liriodendron tulipifera*, L.). Stock of this important forest tree species is commonly produced in forest nurseries for reforestation projects in the eastern states. As the survival of transplants is often largely dependent upon the quality of stock itself, it seems that a knowledge of the behavior of a particular species grown under different nitrogen conditions is essential to production of desirable seedlings.

Hesselman (1917) in his study of the subordinate vegetation associated with regenerating coniferous forests has listed two general groups of plants based on the form of accumulated nitrogen compounds found in the tissues. Those which contain nitrate nitrogen are called "nitratophilous plants," even though they give nitrate tests only when grown in soils high in nitrogen. The other group includes those species which do not show an accumulation of nitrate nitrogen under similar conditions.

Schimper (1890) found quite inconsiderable amounts of nitrate nitrogen in the tissues of tree seedlings grown on compost soil very rich in nitrates. From analyses made on various parts of apple trees on plots which had been supplied with varying quantities of nitrate nitrogen, Gourley (1915) found

*Papers from the Department of Botany, The Ohio State University, No. 315.

no correlation between the amounts of nitrate nitrogen in the tissues and the amounts added to the soil. In all cases, the nitrate nitrogen present in the trees was almost negligible.

Busgen (1917) quotes Ebermayer (1882) as having found the woody cylinder poor in nitrogen, 0.17 percent of its dry weight. Fallen leaves of beech, spruce, and pine contained 1.34, 1.06, and 0.91 percent respectively of nitrogen. Dried green leaves of oak and elm at the end of July showed 2.30 and 1.87 percent nitrogen. He estimated that the nitrogen requirement per acre per year for the beech forest is 45.5 pounds. According to Passler (1893), most of the nitrogen absorbed by roots accumulates in the leaves, only one-fourth to one-fifth is stored in the stem. Gaumann (1928) found 0.07 and 0.08 percent protein respectively for the heartwood and sapwood of *Abies pectinata* and 0.05 and 0.06 percent protein for the heartwood and sapwood of *Picea excelsa*.

According to Falkenstein (1913), Hesselman (1917), Weidmann (1924) and others, nitrate nitrogen seems to be the best source of nitrogen for forest trees. The "more exacting" broad-leaved tree species, especially the young growths, respond well to nitrification in the soil. Wherry (1926) reports studies in Finnish forests by Ilvessalo (1923) which show definite correlations between the increment of the trees and nitrogen content of the soil. Fertilizer investigations at the Savenac forest nursery, Haugen, Montana, by Wahlenberg (1930) showed that seedlings given a heavy application of a nitrogenous compost were twice as tall and had much thicker stems than plants in check plots.

From investigations on tomato plants, Kraus and Kraybill (1918) described the relationship between the amount of available nitrogen and the development of shoot and roots, that is, a high nitrogen supply is associated with a greater shoot than root growth, and a low nitrogen supply is associated with a greater root than shoot growth. Wahlenberg's work also shows a shoot-root ratio of 2.2 for heavily fertilized Englemann spruce seedlings, based on oven-dry weights, as against 1.75 for unfertilized seedlings. Chandler (1919) in a study of peach trees, concluded that the addition of nitrates to the soil is associated with a greater development of top than roots.

Wahlenberg observed that many thrifty, dominant Engelmann spruce seedlings in heavily treated beds develop yellowish tips on mature needles quite unlike the yellowishness of needles

developed in poor soil. Reid (1930) observed mottling in squash leaves after extra nitrogen was supplied.

The purpose of this paper is to describe the effects of different quantities of ammonium nitrate upon the distribution of nitrogen compounds and growth responses in tulip poplar seedlings under a given environment.

PRODUCTION OF EXPERIMENTAL MATERIAL.

One year old tulip poplar seedlings were used in these experiments. They were selected from a lot obtained late in November, 1929, from the state forest nursery near Marietta, Ohio. The selected seedlings were placed in cold frames where they remained until March 15, on which date they were potted in one-gallon, white, glazed, earthenware jars.

TABLE I.

AMOUNT OF AMMONIUM NITRATE ADDED PER JAR IN EACH UNIT OF FIVE AND THE NITROGEN EQUIVALENT PER ACRE OF 2,000,000 POUNDS OF SOIL.

Unit	Number Plants in Unit	Grams of NH_4NO_3	Pounds of N per Acre
1	5	0.000	0
2	5	0.142	20
3	5	0.284	40
4	5	0.710	100
5	5	1.420	200
6	5	2.840	400

Clermont silt loam was used as the medium for growth, principally because of its small content of organic matter. The air-dry soil was thoroughly mixed and sifted through a 36-mesh sieve to insure uniform composition. A definite amount of the silt loam, 5520 grams, was placed in each of thirty weighed jars after nitrogen in the form of ammonium nitrate had been thoroughly mixed with the soil of each unit except that of five check jars.* Table I gives data for the addition of nitrogen. An estimation of the amount of nitrogen absorbed by the seedlings during the first season showed it necessary to make a second similar application of ammonium nitrate in the spring of 1931.

The optimum moisture content of the soil was taken as 50 percent of the amount of water necessary for saturation,

*The term, "unit," will be used to designate any group of five jars having similar applications of nitrogen.

(Ref. in Emerson, 1925). After transplanting a weighed seedling to each jar, enough distilled water was added to give the desired moisture content.* While it was not possible to keep the moisture content of the soil constant, check weighings were made from time to time. Rapid evaporation from the soil surface was prevented by covering the top of each jar with a circle of paraffined cardboard.

The potted plants were arranged on tables in a greenhouse room where they remained during the two growing seasons. In order that the effects of the environmental factors might be equalized for all plants, the jars were frequently shifted on the tables. They were placed in cold storage from November 1, 1930, to March 15, 1931.

In an attempt to avoid any introduction of a non-nitrogenous base as a variable soil factor which might greatly influence the concentration of hydrogen ions, ammonium nitrate was used as the source of nitrogen. On May 25, 1930, the pH value of a soil solution from each unit was determined by means of a quinhydrone potentiometer. Following are the results:

Units	1	2	3	4	5	6
pH value.....	4.88	4.88	4.64	4.55	4.44	4.44

Ten c. c. of distilled water and 10 grams of air-dry soil were thoroughly mixed to obtain a solution.

Total nitrogen determinations by the modified Kjeldahl method on the Clermont silt loam, before additional nitrogen was supplied, showed 600 pounds per acre.† Further total nitrogen determinations were made at the conclusion of the experiment on the soil of each unit, giving the following results:

Units	1	2	3	4	5	6
Pounds of N. per acre based on air-dry weight.....	300	560	640	760	840	980

Ten gram samples in duplicate were used for each determination.

*All water used throughout the two growing seasons was distilled.

†All necessary corrections for the reagents were made in nitrogen determinations by the Kjeldahl method.

TABLE II.

MAXIMUM AND MINIMUM RANGES OF AIR TEMPERATURE AND RELATIVE AIR HUMIDITY INSIDE THE GREENHOUSE FOR GROWING SEASONS OF 1930 AND 1931.

TEMPERATURE.

1930	May	June	July	Aug.	Sept.	Oct.	Nov.
Range of max. temp.	60–105	70–102	82–107	70–105	66–92	59–93	83–101
Range of min. temp.	47–67	49–75	49–78	47–77	44–65	41–73	69–77
Max. range any one day	67–105	64–102	58–104	54–100	47–88	41–81	72–101
Min. range any one day	61–71	62–78	67–82	61–70	61–66	70–73	76–83

RELATIVE AIR HUMIDITY.

Range of max. hum.	52–89	69–95	61–95	61–95	79–95	52–94	41–61
Range of min. hum.	13–72	24–79	20–55	19–88	22–78	15–73	10–55
Max. range any one day	29–89	24–85	30–92	19–91	28–91	21–80	10–50
Min. range any one day	72–84	79–95	55–89	88–95	72–91	65–68	55–61

TEMPERATURE.

1931	Mar.	April	May	June	July	Aug.	Sept.
Range of max. temp.	73–96	66–101	66–99	85–105	88–106	73–105	75–108
Range of min. temp.	60–76	46–74	54–70	57–77	58–78	59–78	59–78
Max. range any one day	60–96	55–101	60–99	62–102	66–102	69–104	66–107
Min. range any one day	60–73	68–75	62–70	61–85	65–80	64–73	78–87

RELATIVE AIR HUMIDITY.

Range of max. hum.	50–77	45–96	50–90	70–90	69–87	69–90	80–89
Range of min. hum.	25–59	17–75	23–75	23–65	18–67	22–81	30–72
Max. range any one day	28–77	30–96	23–82	23–81	21–82	28–84	30–81
Min range any one day	49–51	75–80	75–84	81–89	67–87	81–89	72–89

During the course of the experiment, no attempt was made to control the atmospheric factors of the environment other than reducing the light intensity which otherwise had deliterious effects upon the seedlings on bright summer days. This was accomplished by coating the greenhouse glass with a lime-sodium chloride-water mixture not easily washed away by rain. Measurements of such major factors as air temperature, relative air humidity, and soil temperature were made, and relative light intensity was compared with that of full daylight.

Air temperature and relative air humidity (Table II) were recorded on charts by a hygro-thermograph which remained throughout both seasons near the center of the group of potted plants.

TABLE III.

MAXIMUM AND MINIMUM RANGES OF SOIL TEMPERATURE FOR GROWING SEASONS OF 1930 AND 1931.

	TEMPERATURE.						
1930	May	June	July	Aug.	Sept.	Oct.	Nov.
Range of max. temp.....	56–88	60–87	68–89	70–88	61–88	56–80	68–81
Range of min. temp.....	45–68	52–76	57–78	60–81	58–72	55–72	70–76
Max. range any one day...	65–82	68–84	64–87	65–78	66–81	58–76	70–78
Min. range any one day...	70–76	67–74	72–82	68–79	67–78	63–70	66–70

	TEMPERATURE.						
1931	May	June	July	Aug.	Sept.	Oct.	Nov.
Range of max. temp.....	63–78	67–84	68–86	72–90	68–88	74–91	64–87
Range of min. temp.....	63–72	58–70	57–69	62–78	65–80	68–79	66–81
Max. range any one day...	68–82	62–84	73–82	69–85	73–87	70–86	68–83
Min. range any one day...	73–78	64–73	68–74	75–87	72–80	69–77	67–78

The soil temperature (Table III), recorded by a soil thermograph, showed much more uniform diurnal changes and a much narrower range than the air temperature. The daily maximum temperature usually trailed the maximum air temperature approximately one to one and one-half hours, occurring from two-thirty to three-thirty o'clock in the afternoon.

The Eder-Hecht "Graukeil" photometer with Solio paper, was used to determine the total light intensity of the daylight period inside and outside the greenhouse for various periods throughout both seasons. In all instances, the photometers

were loaded and placed in a horizontal position one night and read the following night. If the out-of-doors reading each time is assumed to be 100, at no time did any one of the simultaneous indoor readings fall outside the range, 83–92. The relation existing between the accumulative light intensity to which the seedlings were exposed and that of full daylight of a cloudy day did not vary from a similar relation on a clear day. These measurements are not intended to give the absolute intensities in both situations, but to show the relative intensity of light to which the seedlings were exposed as compared with that of full daylight.

Measurements of other environmental factors are not offered in an attempt to explain any correlation that may exist between them and the behavior of the plants, but as partial description of the conditions under which the seedlings were grown.

The plants were removed from the jars on September 15, 1931, the soil carefully washed from the roots and all necessary measurements made.

NITROGEN CONTENT OF PLANTS.

The analyses of the tulip poplar seedlings include both nitrate and total nitrogen determinations. These were made on the root, bark, and woody cylinder of plants of the original lot at the time of potting and of plants of each unit at the conclusion of the experiment and on the leaves of each unit at the end of each growing season, including leaves which fell during the period.

Methods.—The material from each part of the plants was weighed on analytical balances and dried to constant weight at 85° C. It was then transferred to weighed, ether extracted extraction thimbles, each loaded thimble weighed and extracted with 80 percent ethyl alcohol until the extract became clear, usually for a period of ten to twelve hours. The extracted loaded thimbles were dried in an 85° C. oven to constant weight. The extractions were made with Soxhlet extractors attached to water-jacketed condensers. Constant heat was applied by means of an electric hot plate.

The content of each thimble was at once finely ground in a food pulverizer and stored in a tightly stoppered vial. The extract was made up to volume, at 20° C., with 80 percent

ethyl alcohol on the basis of one liter of extract for 50 grams of fresh material. The solution was kept in rubber stoppered Erlenmeyer flasks until analyses could be made.

Nitrate and total nitrogen, including nitrate nitrogen, determinations were made on the extracts. Aliquots of 100 c. c. of each alcoholic extract, placed in 800 c. c. Kjeldahl flasks, were evaporated down to 10 c. c. After the samples had cooled, 400 c. c. of distilled water was added. The solution was made slightly alkaline by the addition of a few drops of 50 percent sodium hydroxide. A small amount of Devarda's alloy was mixed with the contents of each flask to reduce any nitrate nitrogen present to ammoniacal nitrogen. The flasks were immediately connected with a still and distillation carried

TABLE IV.

Percent of Nitrogen Based on Both Fresh and Dry Weight of Seedlings from Original Lot.

Plant Part	On Fresh Weight Basis			On Dry Weight Basis		
	Alcoholic Extract	Residue	Total N	Alcoholic Extract	Residue	Total N
Bark	0.09	0.58	0.67	0.18	1.22	1.40
Woody cylinder	0.08	0.14	0.22	0.16	0.26	0.42
Root	0.10	0.26	0.36	0.33	0.87	1.20

on slowly for an hour. The receiving flasks contained 50 c. c. of saturated solution of C. P. boric acid, approximately a 4 percent solution. As any ammonium was bubbled into the acid solution, ammonium borate was formed. This was then titrated with N/14 sulphuric acid. By simple calculations, the amount of nitrate nitrogen present was found.

Approximately 35 c. c. of concentrated sulphuric acid and 10 grams of a salt mixture of potassium sulphate, ferrous sulphate, and copper sulphate, in the proportion of 10 to 1 to 0.5, were added to the remaining content of each Kjeldahl flask and the whole placed over a gas flame until digestion of all organic matter was complete. After cooling, 400 c. c. of water was added to each flask and the content made decidedly aklaline with 50 percent sodium hydroxide. Distillation was again carried on for one hour. As for nitrate nitrogen, the receiving flasks contained 50 c. c. of a saturated solution of boric acid and after distillation titrated with N/14 sulphuric acid.

TABLE V.

PERCENT OF NITROGEN BASED ON BOTH FRESH AND DRY WEIGHT OF LEAVES OF 1930 GROWING SEASON AND OF ALL PLANT PARTS FOR 1931 SEASON.

BASIS FOR CALCULATION OF N PERCENT	MATERIAL ANALYZED	POUNDS OF N ADDED PER ACRE PER YEAR					
		0	20	40	100	200	400
LEAF, 1930.							
Fresh weight	Alcoholic extract	0.04	0.09	0.12	0.15	0.18	0.23
	Residue	0.10	0.12	0.13	0.14	0.17	0.18
	Total	0.14	0.21	0.25	0.29	0.35	0.41
Dry Weight	Alcoholic extract	0.05	0.11	0.15	0.18	0.23	0.29
	Residue	0.51	0.62	0.63	0.71	0.88	0.91
	Total	0.56	0.73	0.78	0.89	1.11	1.20
LEAF, 1931.							
Fresh Weight	Alcoholic extract	0.02	0.03	0.05	0.09	0.11	0.25
	Residue	0.28	0.37	0.41	0.56	0.65	0.90
	Total	0.30	0.40	0.46	0.65	0.76	1.13
Dry weight	Alcoholic extract	0.08	0.16	0.24	0.44	0.54	1.16
	Residue	0.95	1.36	1.45	2.11	2.35	3.89
	Total	1.03	1.52	1.69	2.55	2.89	5.05
BARK, 1931.							
Fresh weight	Alcoholic extract	0.03	0.04	0.06	0.07	0.16	0.20
	Residue	0.35	0.46	0.59	0.69	0.82	1.23
	Total	0.38	0.50	0.65	0.76	0.98	1.43
Dry Weight	Alcoholic extract	0.06	0.07	0.15	0.17	0.37	0.46
	Residue	0.61	0.83	1.10	1.25	1.47	2.06
	Total	0.67	0.90	1.25	1.42	1.84	2.52
WOODY CYLINDER, 1931.							
Fresh weight	Alcoholic extract	0.01	0.03	0.06	0.07	0.08	0.15
	Residue	0.21	0.24	0.32	0.32	0.33	0.37
	Total N	0.22	0.27	0.38	0.39	0.41	0.52
Dry weight	Alcoholic extract	0.02	0.06	0.12	0.13	0.15	0.27
	Residue	0.39	0.40	0.53	0.54	0.55	0.61
	Total N	0.41	0.46	0.65	0.67	0.70	0.88
ROOT, 1931.							
Fresh weight	Alcoholic extract	0.06	0.15	0.24	0.35	0.40	0.55
	Residue	0.24	0.39	0.51	0.64	0.81	0.98
	Total N	0.30	0.54	0.75	0.99	1.21	1.53
Dry weight	Alcoholic extract	0.19	0.51	0.83	1.18	1.37	1.80
	Residue	0.61	0.89	1.23	1.70	2.11	2.55
	Total N	0.80	1.40	2.06	2.88	3.48	4.35

Similar modifications of the Kjeldahl method were employed in determining the total nitrogen of the extracted residue as in the analysis of the extracts. Two gram samples of the residues were used.

Checks were run to detect any nitrogenous impurities in the reagents.

Results.—The results obtained from the analysis include in the extract those nitrogen compounds soluble in 80 percent ethyl alcohol and in the residue the nitrogen compounds insoluble in 80 percent ethyl alcohol. Each form is expressed in percent based on both fresh and dry weight of the plant part analyzed. Also, the total nitrogen, including nitrates, is shown for each of the plant parts in Tables IV and V. Since in no case was there enough nitrate nitrogen found to exceed the limit of experimental error, no further record has been made of these findings.

Figures 1, 2, 3, 4, and 5 show more clearly the relationship existing between the nitrogen content of the soil and the distribution of nitrogen in the seedlings.

Discussion.—Table V shows in detail the distribution of nitrogen in the seedlings. It may be observed that the percent of total nitrogen in the several parts of the plants analyzed increases with the increase of nitrogen in the soil medium. It may also be noted that the ratio between the percentage of total nitrogen in each plant part and that of its soil medium is not a constant one throughout the series. The nearest approach to a constant ratio occurs for the leaves of the 1931 season. While both the soluble and insoluble nitrogen in 80 percent ethyl alcohol increase with the soil nitrogen, the rate of increase of the latter is somewhat the smaller of the two in most cases. Total nitrogen, based on dry weight, was present in the greatest abundance in the leaf material and decreased in order in the root, bark, and woody cylinder. The woody cylinder was the only part which contained less than one percent of total nitrogen in all units, the alcohol soluble nitrogen being exceptionally small. The high percentage of nitrogen found in the leaves corresponds closely to the results of investigations by Ebermayer of various tree species.

If tulip poplar were a nitrate accumulating species, one would have expected an increase of nitrogen in the plant, corresponding to the increase of the element in the soil, but

such did not occur. It is evident that a greater percentage of nitrogen was absorbed by plants of the units high in nitrogen than those containing a small amount; but analyses showed that, even though the nitrate nitrogen had entered the plant as such, it was transformed almost immediately into some other soluble form.

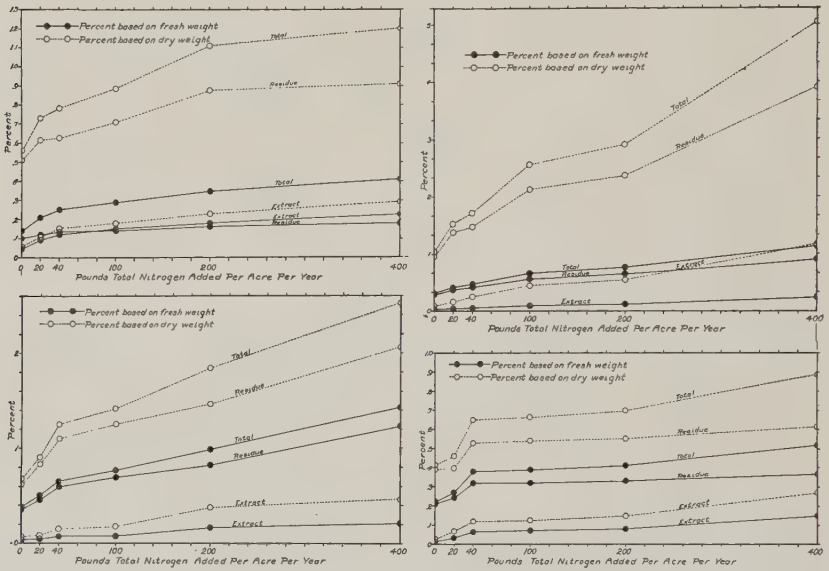

FIGURE 1. (*Upper left.*) Percentage of nitrogen, based on both fresh and dry weight, present in 1930 season leaves from the six units.

FIGURE 2. (*Upper right.*) Percentage of nitrogen, based on both fresh and dry weight, present in 1931 season leaves from the six units.

FIGURE 3. (*Lower left.*) Percentage of nitrogen, based on both fresh and dry weight, present in bark from the six units.

FIGURE 4. (*Lower right.*) Percentage of nitrogen, based on both fresh and dry weight, present in woody cylinder from the six units.

GROWTH RESPONSES.

Effects of Nitrogen on Leaf Color.—As early as the middle of July, 1930, very distinct differences in the green color of the leaves had developed in seedlings supplied with the varying amounts of nitrogen. This condition was quite noticeable throughout the remainder of the first season and all of the 1931 growing season. Leaves of the check plants were decidedly greenish-yellow. Those on the plants showing the higher growth rates contained the smaller quantity of chlorophyll.

Many of the mature leaves in the middle and upper parts of the crowns showed a browning of only the tips and persisted for several weeks, while some of the lower leaves became entirely brown and abscissed. The green pigment was somewhat better developed in the seedlings of unit two. All leaves of unit three except a few on one plant appeared much darker

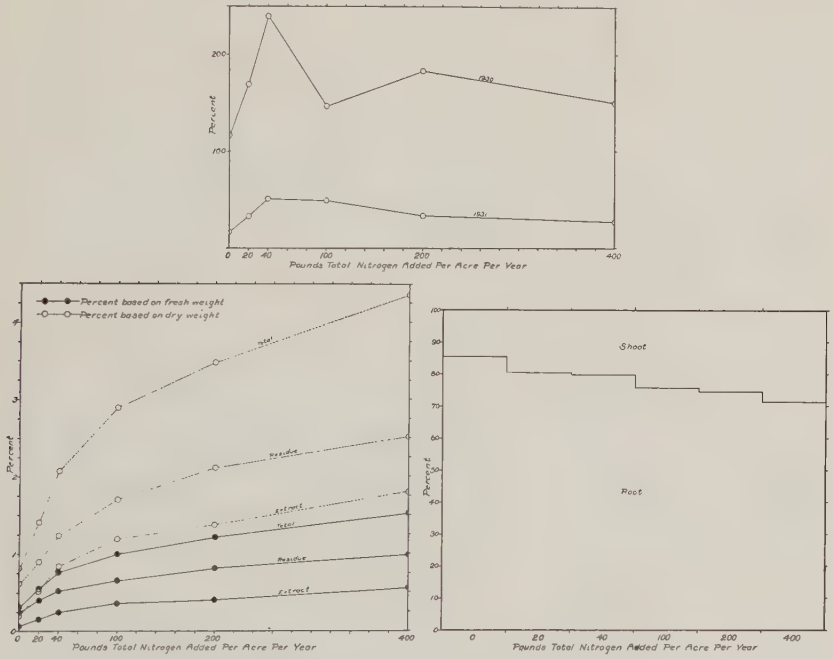

FIGURE 5. (*Lower left.*) Percentage of nitrogen, based on both fresh and dry weight, present in roots from the six units.

FIGURE 6. (*Upper.*) Relative percent increase in height of seedlings for growing seasons of 1930 and 1931.

FIGURE 7. (*Lower right.*) Percentage of shoot and root based on the total fresh weight of the individual units.

green in color. In units four and five, the leaves had a uniform dark green color; none of the lower ones showed browning. In the leaves of unit six, there appeared a blotching of yellow and green on the mature and overmature leaves. The latter soon turned brown and abscissed. Only the young leaves were free of the mottled effect.

It has been generally observed that a uniform yellowish-green color of leaf accompanies, in most plants, low available

nitrogen, which limits the development of chlorophyll. The green and yellow mottled effect of leaves associated with an excess of available nitrogen is due to a decomposition of chlorophyll after the development of a dark-green color in the early

TABLE VI.

VARIOUS STAGES OF EACH SEEDLING IN THE BREAKING OF DORMANCY IN THE SPRING OF 1931.

DATE OF OBSERVATION	CONDITION OF PLANT	POUNDS OF N ADDED PER ACRE PER YEAR																												
		0					20					40					100					200					400				
1931		Individual Plants																												
		1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
March 24	Buds swelling																														
	Buds bursting																														
	Leaves unfolding	x	x		x	x													x	x		x	x	x	x	x	x	x		x	x
	In full leaf																														
March 30	Buds swelling																x														
	Buds bursting						x	x		x				x		x		x	x			x									
	Leaves unfolding			x								x	x		x											x			x		
	In full leaf	x	x		x	x													x	x		x	x	x				x	x		x	x
April 5	Buds swelling																														
	Buds bursting								x																						
	Leaves unfolding							x		x				x		x	x	x	x												
	In full leaf	x	x	x	x	x	x				x	x	x		x					x	x	x	x	x	x	x	x	x	x	x	x
April 11	Buds swelling																														
	Buds bursting																														
	Leaves unfolding																														
	In full leaf	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x

stages of growth. The concentration of nitrogen in the soil medium, at which mottling appears, depends upon the amount immediately available. Since nitrogen in the form of ammonium nitrate was at once available and there was no leaching from the jar, the toxic effect for tulip poplar appeared at a comparatively low concentration. The writer (1931) found mottling

in white elm leaves grown under the same conditions as the mottled tulip poplar leaves.

Relative Dormancy.—Both the time at which dormancy began in the autumn and the time of breaking of dormancy in the spring were relatively earlier, the greater the concentration of nitrogen in the soil medium. As previously mentioned, lower leaves of the seedlings at the limits of the series were turning brown and abscissing as early as July 15; leaf fall continued from these plants until none remained on those in unit six by September 25. A week later, leaf fall for the seedlings of units one and two was complete. A few leaves still persisted, and many terminal buds showed active growth on the plants of units three, four, and five at the time of storage, November 15. Buds showing active growth in the late autumn were killed by the low temperatures during storage.

TABLE VII.

PERCENT INCREASE IN HEIGHT OF SEEDLINGS FOR GROWING SEASONS OF 1930 AND 1931, BASED ON HEIGHT AT BEGINNING OF EACH SEASON.

AVERAGE PERCENT INCREASE FOR SEASON	POUNDS OF N ADDED PER ACRE PER YEAR					
	0	20	40	100	200	400
1930	117.7	169.8	241.4	147.0	184.6	151.0
1931	16.6	34.4	51.0	49.6	33.0	27.4

During the following spring, the plants of the series broke dormancy in the same order as dormancy began. Table VI shows the various stages of each seedling in the breaking of dormancy as observed at intervals of six days.

The time of beginning and breaking of dormancy of a species is of considerable ecological importance, and results for tulip poplar show that high and low available nitrogen favor an early beginning and early breaking of dormancy while intermediate quantities of available nitrogen favor a later beginning and a later breaking of dormancy.

Height Increase During Growing Season.—The increase in height of all plants was determined in centimeters for each of the growing seasons. The average increase for each unit was calculated and its percentage of the average original height of the seedlings in the unit found for the first season. The

percent increase for the second season was based not on the average original height, but on the average height at the beginning of the second season. The results of the measurements are shown in Table VII.

To more clearly show the dissimilarity between the results of the two seasons' growth, they have been further recorded in graph form, Figure 6 (page 175).

It may be noted from Table VII and Figure 6 that, during the 1930 season, the seedlings did not show a height growth curve similar to that of the 1931 season. The irregularity is perhaps due to a "transplanting shock," principally a disturbance of the root systems. Wahlenberg, who tested the effects of various amounts of nitrogen on Engelmann spruce seedlings, found "Increases in growth were slight and, . . . , were not in evidence until the second year, even though the

TABLE VIII.

AVERAGE PERCENTAGE OF INCREASE IN FRESH WEIGHT OF TULIP POPLAR SEEDLINGS OVER THE WEIGHT AT TIME OF POTTING.

	POUNDS OF N ADDED PER ACRE PER YEAR					
	0	20	40	100	200	400
Average percent increase in weight...	132.5	263.8	356.8	432.2	317.4	260.8

fertilizer used was in readily soluble form. During its first year a tree seedling naturally expends much energy in root development at the expense of top growth. After having spent a year developing roots it seems better able to absorb nutrients and use them for further growth of the seedling as a whole, especially for top growth."

Total Increase in Weight.—The total percent of increase of weight of the seedlings was based upon an average of the original weight of the one year old seedlings and final fresh weights for each unit. In either case, the plants were weighed without leaves, and the results in Table VIII do not include leaf weight. The combined leaf material for each unit for both seasons has a similar relation to the concentration of nitrogen in the soil as that of the plants as weighed.

Probably, the best indication of favorable conditions for growth of plants is the increase in weight. Table VIII shows

that of the six media used the medium of unit four afforded these conditions. A close parallelism exists between data of Tables VII and VIII.

Shoot-to-Root Ratios.—At the conclusion of the investigation, the plants of each unit, carefully washed and dried with blotting paper, were cut into two parts, roots and shoots, and weighed separately. All fibrous roots broken in removing the plants from the soil medium were sifted out and included in the weights. Due to the decay and sluffing off of numerous small roots of plants of unit six, the shoot-root ratio for that group may be slightly too high. Figure 7 contains the shoot and root percentages based on the total fresh weights of the individual units.

TABLE IX.

AVERAGE SHOOT-ROOT RATIOS BASED ON FRESH WEIGHT FOR THE PLANTS OF EACH UNIT.

	POUNDS OF N ADDED PER ACRE PER YEAR					
	0	20	40	100	200	400
Shoot-root ratios.....	0.15	0.24	0.24	0.32	0.33	0.38

While the ratios of shoots to roots, Table IX, based on fresh weights are not necessarily indicative of the kinds or quantity of shoots and roots produced, they are an expression of the relative growth rates in the two organs. The fact that there existed a very small difference in the moisture content of similar tissues of plants grown in soil media with varying amounts of nitrogen makes the data more significant. This difference was much less than the difference in succulence of the seedlings indicated. It may be seen from the data, Figure 7 and Table IX, that the large shoot in proportion to the root is associated with a high amount of nitrogen in the soil and the small shoot in proportion to root with a deficiency of nitrogen.

SUMMARY.

The effects of various amounts of nitrogen on potted tulip poplar seedlings have been studied, and the following summary statements are based on plants grown only under the set of conditions described.

1. An insignificant amount of nitrate nitrogen accumulated in the tissues of tulip poplar seedlings regardless of the concentration of ammonium nitrate added to the soil medium.

2. Alcohol soluble nitrogen existed in much smaller quantities in plants of all units than did the alcohol insoluble nitrogen. While the rate of increase of both the soluble and insoluble nitrogen increased with the amount of the nitrate salt supplied, the rate of increase of the soluble form in the seedlings was much greater.

3. The total nitrogen, including nitrate nitrogen, was most abundant in the leaf and decreased in order in the root, bark, and woody cylinder.

4. (a) Leaves of plants supplied with little or no extra nitrogen had uniformly yellowish-green leaves.

(b) Leaves of plants supplied with additional nitrogen equivalent to 40, 100, and 200 pounds per acre had a uniformly dark-green color.

(c) Leaves of plants supplied with the highest amount of additional nitrogen developed at maturity a mottled green and yellow color.

5. Plants growing in the soil media having the highest and lowest concentrations of nitrogen began and broke dormancy relatively earlier than plants of the other units.

6. No definite correlation was noted between the height growth of the seedlings and the amount of the available nitrogen during the first season after transplanting. However, the greatest average height was attained during the second season by plants grown in soil media with nitrogen equivalents of 40 pounds and 100 pounds added per acre per year, the heights decreasing with greater and smaller amounts.

7. The greatest average weight of plants occurred with the addition of the equivalent of 100 pounds of nitrogen per acre, the average weights decreasing with the increase and decrease of nitrogen.

8. An increase of the shoot-root ratio was associated with the increase of the nitrogen supply.

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The Problem of Teaching.

This volume presents the results of service studies carried on by various teachers and administrators of the Ohio State University. While these studies were of necessity attempts to solve particular problems in specific locations in the educational field, the methods used and the results achieved are of wide significance. No one interested in the progress of education can afford to overlook them.

Modern methods of teaching are discussed by those using them; the results of modern methods of teaching are viewed through the medium of suitably prepared objective examinations. Remedial methods for the students not responding normally, as well as special methods and encouragement for the superior students, are developed. Broad surveys of general fields round out the volume, which is a real contribution to higher education.—L. H. S.

Service Studies in Higher Education, by eighteen members of the staff of the Ohio State University. VIII + 283 pp. Bureau of Educational Research Monographs, No. 15. Columbus, Ohio State University, 1932. $2.00.

COLOR IN VARIOUS PLANT STRUCTURES AND THE SO-CALLED PRINCIPLE OF SELECTIVE ADAPTATION.

Studies in Determinate Evolution, VII.*

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In the lowest, living vascular plants there is usually very little color aside from the general green of the chlorophyll. This applies to the ferns, the flowerless clubmosses, and even to the lower, flower-bearing clubmosses and horsetails. In the higher clubmosses the cones sometimes become yellow and the highest horsetails have their fertile shoots and cones destitute of the green color of the sterile shoots. As one progresses upward through the flower series to the higher plants, more color is evolved and usually not only a greater diversity of tints in the various species, but also a much more complicated color chemistry in the individual petals and other parts, distributed in spots, dots, stripes, blotches, etc. This is because the higher plants as a general rule develop a more and more complex system of hereditary potentialities which come into play with the complex physiological gradients and states initiated in the developing inflorescence, flowers, and fruits and also in the purely vegetative parts.

In the general evolution of the flower, the movement is continually toward a more prompt determination of the floral axis, which commonly results in very small flowers as the final condition. In the more extreme reductions there is thus a strong tendency to eliminate the color because the corolla or even the entire perianth is lost. Thus in both bisporangiate and monosporangiate species the flower clusters are often almost destitute of color. The crowding of small flowers in the higher types of inflorescences may, however, compensate for this reduction movement and the color display may also appear farther down the axis, even in the leaves below the inflorescence. Sometimes then in monosporangiate inflorescences there are prominent displays of color even though the individual units

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are inconspicuous. In such species as *Populus deltoides* Marsh. the staminate catkins are a very conspicuous purple-red because of the red anthers, but the carpellate catkins are inconspicuous because of the pale green color of the ovularies. In some of the intermediate types of flowers like many of the pines, larches, firs, and spruces, the color display is very conspicuous, both because of the intensity of the color itself and because of the size of the cones. Many of the wind pollinated gymnosperms have very conspicuous and showy strobili, both staminate and carpellate, as for example, *Picea abies* (L.) Karst. Some are also very fragrant, like the staminate cones of *Dioon edule* Lindl. Of course, it would be quite ridiculous to claim that the color was to attract the wind, but not more so than to claim that specific colors were evolved to attract insects when we know that the ordinary insects, like the wind, may visit a great diversity of colors even in a single nectar-foraging expedition.

It is interesting to note that teleologists in their zeal to expound and prove the causal relation between color of flowers and insects have almost entirely lost sight of the great host of beautifully colored anemophilous flowers. A very extensive teleological literature on the color and form of flowers and on color patterns in general has been developed in the past hundred and forty years. In 1793 Christian Conrad Sprengel published his treatise on the structure of flowers with special reference to the aid of insects in their pollination. Sprengel said that, "Nature seems to have wished that no flower should be fertilized by its own pollen." This superficial notion became generally accepted after the publication of Darwin's book on the fertilization of orchids by insects, which appeared in 1862, and by papers published by Hermann Mueller in 1873 on pollination of flowers through the aid of insects. Darwin stated that "Nature abhors perpetual self-fertilization." Since for the next twenty-five years natural selection was generally assumed to be the causative agent in evolution, the color of flowers and fruits and color patterns in general furnished themes for whole libraries of books and papers on the subject.

As stated, during the years of rampant speculations of the neodarwinian teleology, one of the most universally exploited phenomena of the flowering plants was the prominent display in these plants of the color of flowers and fruits. All the diverse colors and endless patterns of streaks, lines, spots, dots, dashes, and nets were explained as being the result of a life and death

selecting action by insects and other animals which fed on the pollen, nectar, and fruits. Each spot was a recognition mark, each streak a line to guide the hungry or thirst insect to the proffered stores. Every fantastic pattern was of life and death utility to the possessor and had been acquired through "natural selection" because of its survival value to the individual. The most remarkable phenomenon in this enthusiastic pursuit of pseudo-science was that its devotees never seemed to see the conspicuous and attractive colors in flowers that were visited only by the wind, never seemed to discover the bright colored lines and splotches so common on the stems and leaves of many weeds, whose flowers are not even noticed by insects, never speculated on the attractive value of the underground color of roots. The natural selection delusion followed the same course as have other delusions. The fantastic, teleological explanations exceeded anything ever imagined by the inventors of fairy stories to account for unsolved phenomena of nature. One could write volumes on the absurdities alone which have been perpetuated since the beginning of the twentieth century when De Vries with his mutation theory introduced a wholesome check, which should have brought to an end this unscientific era of "science." But though the teleological citidels of neo-lamarckism and neo-darwinism were badly battered by the mutation theory and the rediscovery of Mendelian heredity, the teleologist defenders did not surrender their beliefs but continue powerful in all lines of speculative philosophy and science up to the present time.

Especially preposterous are some of the Lamarckian explanations in some present textbooks of geology. Birds are said to have originated as follows: "These more active running and bipedal pro-avian lizards probably had their entire body covered with over-lapping scales, and jumping about from branch to branch or tree to tree, learned not only to parachute, but eventually to flop their front limbs in aviation. In these efforts the scales changed into long and complicated fronds and finally became feathers that maintained the body warmth," etc. "In the fishes, the paired fins with their girdles are the rudiments out of which legs and feet were developed through the enforced hobbling of the fringe-finned ganoids in their search for water holes in desert regions." Fishes got lungs in this way. "It is thought that under the stimulus of these changes gill-breathing fishes first adapted themselves to bur-

rowing in the sand. Thus protected in water and mud holes there was for a time moisture to pass over the gills, but under such environments life was very precarious and in the struggle most of the individuals were destroyed. After innumerable failures in their efforts to gulp the air into the pharynx, efforts lasting through long geologic time, the ganoids and lung fishes were gradually developed and perfected." It is difficult to imagine how credulity could invent anything more absurd than these statements.

In present university textbooks of botany, one can read that "butterfly flowers are frequently red, bee-flowers blue or purple." One need only watch a swarm of bees or bumble-bees at work to promptly discover that they exercise no such color preferences. The deductions are the result of philosophical belief rather than accurate observation. I have seen individual bees gathering nectar from flowers of almost every color of the rainbow in the space of a few minutes. The following is a dissertation on "honey-guides:" "In numerous flowers the entrance by which nectar is approached is marked by a ring or flush, colored differently from the rest of the flower, or lines and streaks converge upon it." Of course, one can find such rings and flushes or converging lines in all sorts of plant structures where no nectar is available for the unlucky insect that might be allured by such "guides."

The following is a sample of the popular science of a dozen years ago by a popular writer on nature themes. It is not one particle more ridiculous than what commonly appeared in the standard treatises put out by those who were considered leaders in the realm of scientific thought. "*The dandelion head.* Half the involucre bends downwards to protect the flower from crawling pilferers, half stands erect to play the role for the community of florets within that the calyx does for individual blossoms. Seated on a fleshy receptacle, not one flower, but often two hundred minute, perfect florets generously co-operate. In union there is strength. . . . Each floret of itself could hope for no attention from busy insects; united, how gorgeously attractive their disks of overlapping rays are! . . . Each floret insures cross-pollination from insects crawling over the head, much as the minute yellow tubes in the center of a daisy do. Quantities of small bees, wasps, flies, butterflies, and beetles—over a hundred species of insects—come seeking the nectar that wells up in each little tube and the abundant

pollen, which are greatly appreciated in early spring when food is scarce." Now it will be evident how ridiculous this teleological description is when it is known that our common dandelion is parthenogenetic, the eggs developing new plants without fertilization, and that neither the pollen nor the insects which spread it about are of any use whatever to the plant in its present condition. It has evolved into a highly efficient parthenogenetic species in direct contradiction to the supposed causative selection, produced by insects and its allurements of color and nectar.

Special colors may be present in all parts of plants and its development is due to the evolution of potentialities producing certain chemical reactions or diffraction surfaces which have no relation to survival of the species as the following examples will indicate:

Color of Pollen.—Pollen grains are of many colors. Sometimes they are of the same color as the anthers in which they are contained; sometimes they are of an entirely different color; sometimes the color corresponds with that of the petals, and sometimes it is of an entirely different tint. How foolish to think that the insect, after it had been attracted to the flower, would refuse to gather nectar or the pollen because it happened to be of a different tint from the petals or anthers. The colors of the pollen are as diverse as those of the rainbow. *Koellia incana* (L.) Ktz. has purple anthers and pure white pollen. *Staphylea trifolia* L. has yellow pollen and white petals. *Aesculus glabra* Willd. has orange pollen. *Iris-regelio-cyclas* hybrids (varieties Psyche, Parthenope, Luna, and Hebe) have green pollen. *Saponaria ocymoides* L. has bright blue pollen in blue anthers with a pink corolla as a background. *Geranium sanguineum* L. has blue pollen. *Echium vulgare* L. has light blue pollen. *Lilium pardalinum* Kell. and some other species of Lilium have red anthers and red pollen. *Aesculus hippocastanum* L. has pinkish red pollen. *Dianthus carthusianorum* L. has blue pollen and a dark red corolla. *Claytonia virginica* L. has white pollen in pink anthers. *Sedum ternatum* Mx. has pure white pollen in purple anthers. *Impatiens sultana* Hook. f. has pure violet-purple pollen. *Ipomoea purpurea* (L.) Lam. has pure white pollen. *Iris halophila* Pall. has bright orange pollen. *Leontodon taraxacum* L. has yellow pollen and a yellow corolla. *Lilium longiflorum* Thunb. has bright yellow pollen and white petals. *Linum usitatissimum* L. has white pollen

and a blue corolla. *Papaver orientale* L. has dark purple pollen in anthers of the same color and red petals. *Geranium maculatum* L. has light yellow pollen and light purple petals.

Some plants have pollen in two colors. In *Commelina communis* L. the two, upper, outer stamens have dull whitish pollen while the odd, upper, inner stamen has orange yellow pollen. These differences are caused by the zygomorphic condition and the advanced complexity of hereditary color factors as compared with its near relatives which have pollen of only one color, although the flower as a whole may have just as great a complexity of color potentialities. The duality of pollen color is dependent on the zygomorphic gradients developed in the determinate growth of the flower and not on any advantage or disadvantage to the species.

Why do plants have pollen of such diverse colors? For the same reason that corollas and other parts have such colors, but it is not to attract insects, nor for any other imaginary teleological purpose, but just as in the case of inorganic salts and rocks, so the various parts of living things show a great diversity of colors and color patterns as a part of the universal design of nature.

Color and Texture of Roots.—The parts of a plant that are continually underground are often as brightly colored as those exposed to the light of day and there is also a wide range of tints. In *Equisetum kansanum* Schaffn. and other species the rhizomes are pure black. *Physalis lanceolata* Mx. and *Xanthium pennsylvanicum* Wallr. have pure white roots. *Psoralea floribunda* Nutt. has light-brown roots. In *Toxylon pomiferum* Raf. the roots are orange in color. *Parosela enneandra* (Nutt.) Britt. has lemon-yellow roots. *Morus alba* L. has yellow-orange roots. *Celastrus scandens* L. has bright orange-red roots. *Amaranthus retroflexus* L. has pink roots. *Sansevieria thyrsiflora* Thunb., a common greenhouse species, has bright orange rhizomes and roots. Nearly all of these species, except *Sansevieria*, grow and are eminently successful in dry prairie soils where there are no essential physical differences. So a selectionist will have to fall back on biological factors to account for the differences and in a sarcastic mood it might be suggested that the black rhizomes of Equisetum are a protective coloration adaptation against the ravages of earthworms and gophers, and those roots with bright colors have an attractive value for the denizens of the underground realms of darkness.

Now the same general conditions and discrepancies in respect to color and environment exist above ground, but the enthusiastic, telelogical selectionists apparently never saw the misfits. They had eyes adjusted only according to their teleological or utilitarian faith.

In the same prairie soil the texture of roots also shows that there is no teleological adaptation, no "selective adjustment." All such theorizing is not based on any sound philosophic or scientific principle. It is of the same sort as any witch doctor employs. The supposed process or supposed fact of increasing adaptation is even assumed to be a novel manifestation in the universe, but the supposed "principle of selective adaptation" is not at all true and comes from a lack of a broad knowledge of living things and their phyletic relationships. Bacteria are adapted to survive and thrive through the geological ages as well as dandelions. Amoebas are just as well adapted as men. The fitness of their "adaptation" has nothing to do with their real taxonomic differences.

Returning to the characteristics of roots, we find that their textures are as extremely diverse in the same soil environment as are their colors. A few of the typical dry prairie roots are as follows: *Amorpha canescens* Pursh has exceedingly strong, tough roots. *Morongia uncinata* (Willd.) Britt. has such very brittle roots that they break as readily as sticks of candy. These two deep-rooted plants are often seen growing in the same prairie soil within a foot of each other. To speak of the toughness and brittleness as "adaptations" or the survivals of a "selective adaptation" is the height of foolishness. Other roots have all sorts and conditions of texture in the same soil. There are also all sorts of flavors in these roots. Sometimes very odd "adaptations" are encountered, as in *Equisetum palustre* L., which usually grows in wet soil. It has elastic rhizomes that can be stretched to a considerable extent like rubber. This "adaptation" might be of decided advantage and use in case of an earthquake or landslide! *Raphanus sativus* L. of our gardens has a thick, crisp, fleshy root. The rhizome of *Distichlis spicata* (L.) Greene is hard and rigid not because it grows in saline or alkaline soil, since the same type of rhizome may be found in soils of entirely different character, but simply because such "adaptations" are of no importance to the plant. It could thrive in the same habitat if it had an

entirely different "adaptation." It might be brittle or fleshy for example.

Variously Colored Twigs.—The color of twigs runs through about the same series as that of the roots. One can find almost any general color desired and there are also many ornamental patterns of streaks, blotches, mottlings and speckles. *Euonymus atropurpureus* Jacq. has green twigs. *Cornus stolonifera* Mx. has bright reddish-purple twigs. *Salix lucida* Muhl. has yellowish-brown twigs. *Ulmus americana* L. has brown twigs. In *Cercis canadensis* L. the twigs are dark reddish-brown and speckled. In *Gymnocladus dioica* (L.) Koch. the twigs are mottled white and purplish-brown. In *Amygdalus persica* L. the twigs are red above and green beneath. *Fraxinus americana* L. has dark gray twigs. The twigs of some woody plants and the stems of many herbaceous plants with inconspicuous flowers are striped. *Acer pennsylvanicum* L. has green twigs striped with darker lines. As a general rule the color of twigs is less brilliant than that of roots. This is probably due largely to the difference in the character of the epidermis and cuticle as commonly developed in the two systems. As in the case of the colored roots, to attempt to give a utilitarian explanation to the diversity of color tints of twigs would be extremely irrational, because no such utility is in evidence. These woody twigs grow in the same air and light and are subject to the same heat and cold, to the same dryness and moisture. Leaves have a more pronounced development of color and color patterns, with spots, streaks, and mottlings, than do roots or twigs, and those markings again can have no special utilitarian import. Only a mind of the most extreme credulity or perverted philosophic outlook could conceive of such a relationship.

Color of Plant Juices.—In many plants there are distinctive saps and juices of various chemical composition and these, as would be expected, are also of various colors. Very commonly the juice is colorless although it may have various chemical compounds. *Dicrophyllum marginatum* (Pursh) K. & G. and an endless array of species, genera, and families of plants have white juice, commonly called milky sap or juice. *Chelidonium majus* L. has saffron-colored juice. *Argemone intermedia* Sw. has bright yellow juice. *Sanguinaria canadensis* L. has red-orange juice. *Amorpha canescens* Pursh has bright coral-red juice, which is especially abundant in the young herbaceous

shoots before they become woody. Some species of Boletus, a genus of the Agaricales, have a juice which develops a clear blue color when the plant is broken. To claim that the yellow color of surplur, the white color of common salt, the blue color of sulphate of copper, and the green color of sulphate of iron are caused by "selective adaptation" would be rather foolish; to think that the colors of these plant juices must in some way be the result of "the selective adaptation principle" is equally so and the same observation applies to specific colors on the outside of the plant or animal. But the realms of fancy are infinite and the credulity of natural selectionists is boundless.

Any one studying the taxonomic system carefully will soon find that there is no general correspondence between the system on which we postulate relationships of groups and the so-called adaptations. There are adaptations to various conditions, as to cold, light, dryness, moisture, water, etc., but these do not run parallel with the taxonomic characters. They have little to do with the real fundamental problem of evolution. There is still no evidence whatever for the inheritance of characters acquired through response to environment and even if there were it would be of little consequence in the real problem of evolution. Since there is no direct correspondence between the environment and the taxonomic segregations and series, the hypothesis of either selective adaptation or of adaptation as a response of the individual to the environment is not tenable as an evolutionary causative agent or principle, but is rather the product of minds blindly reacting to an anarchistic belief as to the nature of the universe about us.

Recently, confusion has been introduced between the ideas of "natural selection" and selective elimination. We may have selective elimination whenever an evolutionary movement is proceeding in the presence of an exceedingly adverse environment, but usually the broader more fundamental taxonomic movements are not of such a nature as to produce an eliminative struggle. A lycopod without flowers succeeds in the same environment as one with flowers. A composite with the flowers in heads is just as much adapted to a dry prairie condition and no more so than a legume whose flowers are in a raceme. The epigynous composites or evening-primroses are no better fitted for a dry prairie environment than are hypogynous anemones and poppy-mallows. They all grow side by side. The special "adaptations" are the result of

internal causes as well as are the more fundamental characters which make up the taxonomic system. The "adaptations" are sometimes of use to the individual, but just as frequently they are of no use whatever or they may even be a decided detriment. The evolution proceeds in a given direction not because the environment is producing the change, but because the environment permits the orthogenetic movement to proceed in the given direction. The so-called "principle of selective adaptation" is a delusion, a figment of the imagination, and is contradicted by all the more fundamental evolutionary sequences plainly indicated in any study of the taxonomic system in relation to the environment.

The Action of the Living Cell.

Dr. Fenton B. Turck, whose death occurred a few months before the publication of this book, was a well-known surgeon in Chicago and New York. Over a long period of years he made many contributions to medical literature, many of them being concerned with the problem of surgical shock. As a result of this work he developed his theory of a **cytost,** or shock-toxin, a substance supposedly liberated from cells after their injury or death, affecting the activities of other cells of the body, and, if in sufficient amount, directly or indirectly causing the characteristic symptoms of traumatic shock. In his later years, Dr. Turck carried on considerable experimental work, first in the effort to test his theory, and later with the aim of learning more about cytost and its mode of action. The present book is not only a re-statement of the cytost theory and an account of the author's observations and experiments, but represents also an attempt to interpret these in terms of general cell physiology.

It is only fair to say that the majority of surgeons still regard the cytost theory as unproven. A considerable amount of experimental work by a number of competent investigators seems to indicate that the loss of blood and fluid from the body tissues, which in general accompanies or follows traumatic injury, is not a secondary effect, but is the primary cause of traumatic shock. If these results are substantiated, it will obviously not be necessary to postulate a special shock-toxin to account for most shock phenomena. However, many of Dr. Turck's later experimental results, as described in the present volume, are definitely irreconcilable with this alternative interpretation. The general concept of a cell-product stimulating or depressing the activities of other cells is, of course, firmly established today as a physiological principle. A few investigators, working independently, have also found some evidence (in Bacteria and Protozoa) for a depressing effect exerted upon living cells by products formed through the death and disintegration of other cells. In view of these facts, it is to be hoped that Dr. Turck's later experiments will be carefully repeated in detail by other investigators, and that this important field will be thoroughly explored.

W. J. Kostir.

The Action of the Living Cell. Experimental Researches in Biology. By Fenton B. Turck. xi+308 pp. New York, The Macmillan Company, 1933. $3.50.

TWO NEW SPECIES OF EARTHWORMS FOR OHIO.

HENRY W. OLSON,
S. E. Missouri State Teacher's College.

The author in 1928 listed twenty-two species of earthworms for the State of Ohio. The present paper includes additions to the list previously recorded.

Diplocardia verrucosa Ude, 1895.

This species was first described from specimens collected at Omaha, Nebraska. Frank Smith (1915) states that they are abundant in the soil of bottom-land forests of Illinois and Kaskaskia Rivers.

Length, 7–15 cm. Number of somites, 100–125. Color of anterior dorsal surface pale flesh. Setae widely separated. Clitellum saddle-shaped, situated on somites 13–18, inclusive. Prostate pores on 19, 21. Spermiducal pores in somites 20 and the spermathecal pores in somites 8 and 9. Sperm sacs in 9 and 12.

Only one specimen was collected by the author along the shore of Lake St. Marys in September, 1932.

Helodrilus octaedrus Savigny, 1826.

Known from various parts of Europe, Northern Asia, Iceland and Greenland. In North America it has been reported from Newfoundland and Mexico. Smith (1928) states that this species has been collected from Colorado and Illinois.

Length, 2.5–4 cm. Number of somites, 80–95. Color brownish-violet. Prostomium, epilobic. Clitellum on 28, 29–33. First dorsal pore on 4–5. The spermiducal pores on 15, between b and c. Oviducal pores on 9–10–11–12, in the setae line d. Septal sperm sacs in 9, 11 and 12. Spermathecae usually in 9, 10 and 11. Septal intervals aa, ab,bc, cd, approximately equal; dd somewhat greater than either.

In June, 1929, two specimens were collected near Akron, Ohio. They were found along the bank of the old canal.

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Clitellum	Tubercula pubertatis	Prostate pores	Spermiducal pores	Spermathecal pores	Sperm sacs	Setae	No. of Somites	Length cm.	Color (antero-dorsal)	Name
13–18 sad.		18, 20	19	7/8, 8/9	9, 12	Wide	135–160	20–27	Brown	*Diplocardia riparia*
13–18 sad.		18, 20	19	6/7, 7/8, 8/9	9, 12	Wide	125–160	18–30	Pale	*Diplocardia communis*
13–18 cing.		18, 20	19	6/7, 7/8, 8/9	9, 12	Wide	90–120	4–12	Pale	*Diplocardia singularis*
13–18 sad.		19, 21	20	8, 9	9, 12	Wide	100–125	7–15	Pale	*Diplocardia verrucosa*
15–25		23, 26	19	6/7, 7/8, 8/9	11, 12	Close	165–225	15–20	Pink with blue irridescence	*Sparganophilus eiseni*
22, 23–26, 27	23–25, 26		13	9/10, 10/11 dorsal	9, 12	Close	80–100	4–6	Brown	*Helodrilus tetraedrus* f. *typica*
22, 23–27	23–25, 26		15	9/10, 10/11 dorsal	9–12	Close	80–100	4–6	Brown	*H. tetaedrus* f. *hercynius*
22–29	27, 28		15	None	11, 12	Close	40–60	2–5	Reddish-brown	*H. tumidus*
22–29 or 1/3 30	None		15	None	11, 12	Close	100–110	4–7	Brown-red	*H. gieseleri* var. *hempeli*
24–30	25, 26–29, 30 (indefinite)		15	None	11, 12	Close	90–100	3–4	Brown-red	*H. parvus*
24, 25–31, 32	24, 25–30 (indefinite)		15	None	11, 12	Close	70–100	2–6	Reddish-brown	*H. beddardi*
23, 24–33	None		15	None	11, 12	Close	100–130	7–10	Rose-red	*H. longicinctus*
24, 25, 26–31, 32 or 33	29, 30–31		15	9/10, 10/11	9–12	Close	130–150	4–8	Pale-red	*H. roseus*
24, 25 or 26–32	28–30, 31		15	9/10, 10/11	9–12	Close	75–125	5–15	Brown and buff (bands)	*H. foetidus*
25, 26–31, 32	28–30		15	9/10, 10/11	9, 11, 12	Wide	80–125	5–8	Red	*H. subrubicundus*
26–31	29, 30 (indistinct)		15	None	11, 12	Wide	90–110	4–8	Red	*H. tenuis*
27–34, 35	31, 33		15	9/10, 10/11	9–12	Close	100–250	5–20	Rose-red	*H. caliginosus* f. *typica*
27–34, 35	31–33		15	9/10, 10/11	9–12	Close	100–250	5–20	Rose-red	*H. f. trapezoides*
27–37	None		15	None	11, 12	Close	110–140	10–12	Chestnut-brown (purplish)	*H. zeteki*
28, 29–33	31–33		15	9/10–11/12d	9, 11, 12	Sep.	80–95	2.5–4	Brownish-violet	*H. octaedrus*
27–32	28–31		15	9/10, 10/11	9, 11, 12	Close	90–145	7–13	Reddish-brown (violet)	*Lumbricus rubellus*
29–37	31, 33, 35		15	9/9, 10/11	9–12	Close	80–125	5–7	Greenish	*H. chloroticus*
30–35	31–34		15	9/10, 10/11	9–12	Wide	100–170	5–16	Pale-pink	*Octolasium lacteum*
31, 32–37	33–36		15	9/10, 10/11	9, 11, 12	Close	125–175	15–25	Brown-violet	*Lumbricus terrestris*

APPARATUS FOR THE MAINTENANCE OF CONSTANT TEMPERATURE AND HUMIDITY.

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The exacting demands for accuracy in modern biological research make necessary precise control of temperature and humidity. This paper is intended to set forth certain considerations which enter into the construction and operation of thermostats and humidostats.

AIR THERMOSTATS.

The physical properties of air must be borne in mind in order to be successful in maintaining it as a thermally static system. Salient characteristics of air are its low specific heat, or thermal capacity, and low thermal conductivity. A volume of air contains only one three-thousandth as many calories of heat as a similar volume of water. Hence in a given volume, a small loss or gain of heat produces a relatively great change in its temperature. Conversely, an object surrounded by air of different temperature will be affected very slowly because the air contains such a relatively small amount of energy to impart to the object. So it is that air is such an excellent insulator. For these reasons an air bath needs no elaborate insulation, and it is desirable to use heaters of small size. Moreover, a quick-responding thermoregulator is necessary.

Cabinets in which temperatures are to be held constant do not need to be elaborate or expensive. The success of accurate control depends more upon the perfection of the controlling instruments than upon excess insulation. A double-walled cabinet made of some insulating fiber board such as "Masonite" or "Cellotex," nailed to a light but rigid framework of wood, will give ample insulation for all but extreme temperatures. Dead air spaces of about two centimeters should be provided between layers of insulation. The case should be of air-tight construction.

Long low cabinets are the most practical. Such design gives better air circulation and more floor space. Since ento-

mological experiments are usually carried on in rather small containers, a greater efficiency is enjoyed where there is more floor area and less waste space at the top of the cabinet. A cabinet of good dimensions is 65 to 70 centimeters high, 80 centimeters deep, and as long as desired—perhaps 1.7 to 2 meters. Doors should be wide enough to accommodate good sized trays; moreover, one can work more effectively through an opening which provides ample elbow room. It is a good plan to hinge the door at the bottom to provide a work shelf when it is open. Doors without glass are lighter and more easily made. Observation windows may be built above the doors, thus giving the operator clear vision through the window while working with his hands through the door. Interior illumination is very helpful. A cabinet is more convenient if its floor is on a level with the worker's elbows. The floor should be of some material that is easily washed.

A rapid circulation of air in the cabinet is essential for uniform temperature. A small house fan may be set inside the chamber, or a larger slow-speed motor may be mounted on the outside and belted to a shaft running through the cabinet wall. But such a shaft is difficult to construct, and must be provided with good metal bearings to be free from vibration. A false inner back in the cabinet will form a duct to provide for the return of air to the heating units and fan. One adjustable opening, 15 centimeters in diameter, in the wall behind the fan, is sufficient for a fresh air supply. If an inside fan is used, an adequate cooling system should be provided to offset the heat generated by the motor. It is a good plan to construct a flue, opening through the bottom and top of the cabinet and enclosing the motor of the fan. Convection currents will carry out this troublesome extra heat.

All cabinets should be built to allow maintenance of a constant humidity. From the experience of Richardson, it seems unnecessary to line the cabinet with sheet metal or glass. The walls may be successfully waterproofed with two coats of priming shellac or lead paint, a coat of under-varnish, and two coats of the best waterproof spar; or three coats of "Duco" may be used.

The type of heating unit depends upon the temperature to be maintained. When only a small amount of heat is necessary it is common practice to use electric light bulbs. They are not efficient heaters because they consume more current per calory

of heat delivered than any other type of heater, and consequently overburden the thermoregulator or relay contact points. The points are then much more apt to stick and fail to turn off the heat. The old-fashioned electric room heaters, known as "Luminous Radiator Units," are very satisfactory heaters. They have a large heating surface and very low lag in heat delivery. These factors are vitally important in air conditioning. If such bulbs cannot be obtained, good heaters can be made of bare resistance wire wound on porcelain rods or asbestos. The flat resistance wire used in flat-irons is good. As a matter of fact, an electric heater, with more resistance wire added to reduce the wattage, makes an admirable heater for a high temperature air bath.

To be independent of surrounding temperatures a thermostat must have a cooling system such as cold water flowing through a metal tube. The flow of water may be adjusted so that the heater is off and on for equal periods. A more nearly constant temperature is obtained when the intervals of heating and cooling are short.

In certain situations gas heat might prove superior to electric. A very simple and not inefficient mercury thermoregulator to control the flow of gas to a burner can be purchased or made of glass tubing as illustrated.

WATER BATHS.

Maintenance of constant temperatures in liquid systems is in some ways much easier than in gaseous ones. The calorie content of water per volume is so very much greater than that of air that the heat interchange by conduction between water and the surrounding air is small. Hence careful insulation of the waterbath is not at all necessary. In case of a metal water container, insulation such as one layer of fiber board or an inch-thick layer of newspaper is sufficient. Such a tank will allow maintenance of temperature to within 0.01° C. On the other hand, considerable heat is lost as a result of evaporation from an exposed water surface. The evaporation rate varies with the weather and any draft that may blow. A tight cover over the bath will eliminate this cause of temperature fluctuations. Or if more practical, the water surface may be protected with an inch-layer of pure white oil which will both insulate and stop evaporation.

A good waterbath may be constructed from any one of the many types of non-rusting water containers. Glass aquaria are often desirable if the experiment must be inspected closely. Usually they need no additional insulation. One of the most serviceable types of container is the wooden barrel or hogshead. Barrels are cheap and readily obtained, and they lend themselves to all manner of carpentry for installation of instruments, water pipes, etc. No additional insulation is needed.

Rapid agitation of the water is of cardinal importance for accurate temperature regulation. A small propeller working in a vertical brass tube, so that a down current of water is created within the tube, is an efficient stirrer for a small bath. A heater of the knife-blade type can be placed in the tube and thus insure a rapid distribution of the heated water. Such a stirrer may be connected directly to a small motor, but it is usually more convenient to belt it to a motor located elsewhere. For a larger body of water a good agitator may be made from a piece of heavy sheet brass cut and bent like a boat propeller. This may be fastened to a horizontal shaft passing through the side of the tank and belted to a motor. A surface agitator of the centrifugal type can be fashioned from a vacuum sweeper. The discharge opening should be cut away so that the water will surge out on the same plane in which the fan turns, and the fan blades trimmed down somewhat. It is necessary to connect a large rheostat in series with such a motor to reduce the speed.

Most immersion water heaters on the market are serviceable. The "Luminous Radiator Units" are excellent water heaters. There should be no appreciable lag in heat delivery, but the heating surface presented to the water is not so important if good circulation occurs. A cooling system is a necessity for close temperature regulation.

It is sometimes convenient to pipe water of uniform temperature from the water bath to the instruments or animal chambers than to immerse them in the main body of water. A small brass centrifugal pump taken from a truck engine circulates water through such an outside circuit in the author's laboratory.

THERMOREGULATORS.

Ordinary thermoregulators depend on expansion as the acting force. Hence the coefficient of expansion and thermal conductivity of a substance determine its usefulness as a

thermoregulator medium. Gasses show the greatest volumetric reaction to temperature changes and are most sensitive in effect. However, the great changes in volume of gas produced by fluctuations of barometric pressure obviate the possibility of causing a gas filled thermoregulator to maintain a given temperature. Gas filled wafers are sometimes used in incubators, but they do not give dependable control.

Liquids display a lower coefficient of expansion, but the rate of thermal conductivity is about twenty times as great for liquids as gasses. Fluids offer the most practical solution to the problem of precise temperature control. Metals have a much lower coefficient of expansion than liquids, but they have a high rate of thermal conductivity. In spite of their low sensitivity metals are most frequently used as the agent in thermoregulating devices because a metallic regulator can be built to handle 110-volt current without a relay.

Metallic Thermoregulators.—Of the metallic thermoregulators, the DeKhotinsky type seems to be the most satisfactory. It is made of a metal helix whose torque opens and closes contact points with changes in temperature. They are especially dependable when provided with twin contact points, and under favorable conditions will regulate the temperature to within 0.5° C. Bimetallic or metal-nonmetal regulators will usually keep the temperature to within 1° or 2° C. of that desired, but they are inferior and not overly dependable.

Most metallic thermoregulators are designed to make and break a 110-volt circuit directly without the aid of a relay. The burden thus placed on the breaker points is severe. Only metals having the highest melting points will resist the intense heat of the tiny electric arcs which are produced each time the circuit is broken. If the contact points are broad, the arcs will be diffused over the surface and will be less apt to melt out minute pockets or fuse the points together. Rough contact surfaces cannot meet exactly flush and so they foster arcing and sticking. Contact points are highly polished when manufactured because the reliability of the instrument depends on the mirror surface of the points. Therefore the points should be given good care, and never scraped with a file or knife. If the surfaces become dirty, impregnate soft paper with Jewelers rouge (Ferric Oxide powder) and draw it several times between the points. If they have become pitted so that rouge is insufficient, use the finest emery dust on soft paper or

No. 0000 emery cloth. Finish with a prolonged polishing with rouge, and adjust so that the points make contact over their entire surface. Emergency contact points may be made out of small discs of coin silver highly polished.

It is important to guard against overloading the thermoregulator. As small heating units as possible should be used, and if their combined power consumption is more than 200 watts it is better to split the circuit. When most of the load burns continuously and only a small fraction is in series with the regulator it will adjust the temperature much more accurately.

Liquid Thermoregulators.—For the maintenance of temperatures within a range of less than 0.5° C., it becomes necessary to use liquid as the regulator medium.

The sensitivity of a thermoregulator fluid is determined by the relationship of the specific heat, density, and coefficient of expansion of the thermoregulator fluid, to the specific heat and density of the substance whose temperature is regulated. In other words, the calorie content per volume of the bath medium should be greater than that of the thermoregulator liquid. Such a relationship exists between water and mercury or organic fluids. It seems both in theory and practice that a well designed mercury thermoregulator is not excelled for water baths.

The case of air conditioning is quite different. The calorific ratio is reversed so that air contains much less heat per volume than the regulator liquid. The temperature of the air can change considerably before sufficient energy is transferred to alter the temperature and volume of the liquid. This time factor is apparently responsible for the difficulties encountered in maintaining temperatures in an air bath within less than half a degree. In order to offset this condition it is of unquestioned value to employ an organic fluid in order to benefit by the higher coefficient of expansion (about ten times that of mercury).

Electric Thermoregulators.—Rarely and for the most exact temperature regulation, thermoregulators have been built to make use of the changing resistance of a band of metal, or changing potential of a thermocouple. Such slight electrical variations are recorded by a sensitive galvanometer. A small light beam is reflected from the galvanometer mirror to a light-sensitive cell some distance away. When the temperature rises, the mirror deflects the light beam onto the cell, activating

it to pass a small electric current. This current is amplified in a vacuum tube relay so that it will operate a magnetic relay which breaks the heating circuit. Although complicated, this method has been reported successful in holding temperatures in a very small bath to plus or minus one one-thousandth degree.

Mercury Thermoregulators.—Mercury filled thermoregulators are so frequently used that almost every laboratory has its own design of instrument. Most of them are good, but the one described here is superior in simplicity and ease of construction. It can be quickly made by a person unfamiliar with glass blowing.

A large tube, with bulbous end or not, is slightly flared at the top by heating and spreading with a metal triangle or carbon rod. This tube should hold about one kilogram of mercury. A second piece of glass tubing which will fit snugly into the first is cut about 10 cm. long, and enlarged at one end to form a cup. This may be accomplished by heating and working a hot carbon rod into the bore to swell the tube. A piece of 2 mm. capillary tubing, 5 cm. long is flared very slightly at both ends so that it will just slip into the neck of the second tube. The capillary is coated on both ends with soft DeKhotinsky's cement or "lac-wax,"* preparatory to sealing in the second tube. A copper wire to make fixed contact with the mercury is laid along the side of the capillary and inserted along with it into the neck of the second tube. A gentle warming will melt the wax and seal both capillary and wire in place. This assembly is then inserted in the neck of the mercury reservoir and sealed in place with wax or plaster of Paris. A metal bracket is fastened about the top of the regulator to support the contact wire which extends into the capillary tube. Either a screw or sliding clamp makes a fine adjustment of this wire possible. Platinum wire should be used for the tip of the electrode, since it does not amalgamate with mercury. It may be joined to a copper wire by first welding to constantan wire in a blast lamp and then soldering the latter to copper. Platinum is exceedingly difficult to solder. A temporary joint may be made by cleaning both wires and winding two or three

*"Lac wax" is a convenient sealing compound made of flake orange shellac and pine tar in proportions according to the hardness desired. It is not resistant to strong chemicals, but is more easily handled and much cheaper than DeKhotinsky's cement.

turns of the copper wire about the platinum, then mashing them together and covering the union with sealing wax.

Organic Liquid Thermoregulators.—Toluol is often recommended as a thermoregulator liquid. The author has found carbon tetrachloride much superior except for temperatures above 70° C. Carbon tetrachloride has a slightly higher coefficient of expansion, greater density, is non-inflammable and is cheaper and more easily obtained. Methyl Alcohol is another good regulator fluid for biological work.

A section of unused automobile radiator-core, which holds about two liters, is used as the reservoir for the regulator fluid. Such a container exposes the liquid to a maximum surface per unit volume, insuring a rapid response to the temperature fluctuations of the air. The section of radiator is converted into a tight container by soldering suitable covers over the two ends where openings are exposed. Two copper tubes are soldered into opposite ends of the top. One is short and serves to permit the escape of air during filling; when the container is full and all air excluded this tube is pinched shut and soldered The other tube leads to the glass manometer in which a small droplet of mercury makes and breaks contact with a platinum wire. In order to prevent carbon tetrachloride from dissolving the stop-cock grease and leaking out, or evaporating from the open reservoir, it is necessary to provide for a trap liquid to seal it in the reservoir. A small brass trap chamber, where carbon tetrachloride and water meet, is soldered to the second tube leading from the reservoir. This trap prevents water being drawn into the radiator or carbon tetrachloride coming in contact with the stop-cock. A "T" tube is attached to the trap, one arm of which connects with a stop-cock and filling reservoir, and the other to the glass manometer. The manometer is made of 2 mm. capillary tubing. In the rear arm a small bulb is blown to serve as a trap to prevent mercury from being drawn into the metal part of the instrument. (Mercury will amalgamate with and dissolve soldered joints.) A copper wire is inserted through the rear arm of the glass "U" tube to make contact with the mercury. The manometer tube is cemented to the copper tube with wax, through which joint the contact wire protrudes. To fill the instrument carbon tetrachloride is poured through the filling reservoir until the instrument is entirely full and overflowing at the overflow tube. Then sufficient water is poured in to half fill the trap chamber

At this juncture the overflow tube is pinched together and soldered. Next a droplet of mercury, large enough to fill the "U" manometer up to its trap is introduced through the open end. Finally a rubber tube is slipped over the free arm of the manometer and water run past the mercury in its trap until all air has been expelled from the connecting tubes and filling reservoir. The mercury drops back into place as soon as water ceases to flow past. The excess water can then be removed and a platinum electrode inserted into the free arm.

The adjustment of this thermoregulator to any desired temperature is quick and easy. When the stop-cock is open, the mercury in the "U" tube will stand at a certain level. The platinum electrode is set very close to the mercury meniscus. The air bath is then heated to the temperature desired and the stop-cock closed. The regulator will then hold the temperature at that point.

Mercury displays considerable adhesion to glass. Therefore, any movable column of mercury tends to stick to the glass with the result that the mercury meniscus is often greatly distorted or movement actually delayed. A lubricant consisting of a 5% solution of Phenylhydrazine Base in dibutyl phthalate will effectively prevent such difficulty.

MOVING CONTACT MECHANISM.

When more exact temperature regulation is desired than an ordinary mercury or carbon-tetrachloride regulator will afford, a device may be installed which will greatly increase the sensitivity of either of these types. Any sort of a mechanism will serve which will continuously lift and lower the platinum contact wire in the capillary tube a distance of one to three millimeters. A frequency of 40 to 60 times a minute is best.

In the case of any fixed contact regulator, there is always a lag in operation behind the temperature of the bath. The bath is overheated before the regulator turns off the heating current and overcooled before contact is made again. Furthermore, the longer the periods of heating and cooling are, the more irregular will be the curve of temperature. When a moving contact is used the alternations of heating and cooling are so rapid that lag in operation is circumvented. Also the temperature curve will be reduced to a nearly straight line. Usually there is no possibility of graduating the amount of heat supplied to a bath—either the heater delivers maximum heat or none.

If a moving electrode is used it produces the effect of a graded temperature change, for when the mercury rises slightly the needle is immersed for a longer fraction of each stroke and the heater therefore delivers a slightly smaller amount of heat per minute. Yet it does not let the bath cool rapidly as though it were entirely shut off. Such a delicate tempering of heating and cooling makes possible most exact temperature control.

Besides these, there are other advantages which make an interrupter-regulator more dependable. There is a positive mechanical rupturing of the mercury meniscus, so that the oxide film can never retard or prevent contact being made at the proper instant. Also, the constant agitation of the meniscus keeps it in a more regular form.

Any device which operates smoothly in lifting and lowering the contact wire is adaptable. The author uses a water motor made from a two-ounce salve box. A disc of thin brass is incised from the edge and the sectors turned 90° to make the paddle wheel. The bearings through which the brass axle protrudes are merely pieces of copper tubing soldered to the lid and bottom. The intake is soldered obliquely through the side of the box, with an outlet more than twice as large on the opposite side. A midget pulley with a cam to move the contact wire is belted to the axle of the water motor with a rubber band. A more elegant mechanism is an electric windshield wiper with slightly altered gears. A storage battery supplies current.

The Physiology of Farm Animals.

This book fills a long vacant niche in the literature pertaining to the physiology and nutrition of farm livestock. It was originally planned that this work should appear in two volumes, the first as an application of the general principles of physiology to farm animals, and the second, a volume dealing with animal nutrition. The first volume, by Marshall, was published in 1920 and is now out of print. The publishing of the second volume was abandoned following the death of Professor Wood, the senior author.

The Physiology of Farm Animals, by Marshall and Halnan, is the result of a thorough revision of the first volume, plus the addition of the material originally intended for the volume on nutrition. Therefore, this book includes a wealth of subject material of value to students of agriculture, especially those interested in farm animals and poultry.

The book is well written and amply illustrated. It should find ready acceptance as a textbook or reference for elementary courses in physiology as applied to farm animals.

EDWIN E. HEIZER.

Physiology of Farm Animals, by F. H. Marshall and E. T. Halnan. 366 pp., 118 ill. Cambridge, The University Press; New York, the MacMillan Company, 1932. $3.25.

ADDITIONS TO THE OHIO LIST OF ROBBER FLIES.

(Diptera: Asilidae.)

STANLEY W. BROMLEY.

Since the appearance of my "Preliminary List of the Robber Flies of Ohio," (Ohio State Museum Science Bulletin, Vol. I, No. 2, November 1, 1931), the assiduous collecting of Mr. E. S. Thomas, Curator of Natural History, and Mr. Charles F. Walker, Assistant Curator, has brought to light five additional species hitherto unrecorded from the state. Three of these were not in the hypothetical list. The total number for the state now stands at 70 species.

66. *Leptogaster incisuralis* Loew. Franklin County, ("Red Hills"), September 2, 1932. (C. F. Walker.) At light. Three specimens.
67. *Bombomima champlainii* Walton. Flat Rocks, Lancaster, July 1, 1931. (E. S. Thomas.) One specimen.
68. *Mallophora clausicella* Macquart. Lynx, Adams County, July 30, 31, 1932. (E. S. Thomas and C. F. Walker.) Seven specimens. Fairfield County, Berne Township, August 14, 1932. (C. F. Walker.)
69. *Asilus angustipennis* Hine. Washington Township, Jackson County, August 30, 1931. (E. S. Thomas.) One specimen. A very rare species.
70. *Asilus prairiensis* Tucker. Higby, Ross County (on prairie). June 20, 1931. (C. F. Walker.) One specimen.

In addition, specimens of *Promachus hinei* Bromley (Annals Ent. Soc. America, XXIV, 2, 435, 1931) were collected near the type locality (West Jefferson), at Newport, Madison County, September 5, 1931 (E. S. Thomas), and Franklin County, Big Darby, September 12, 1931 (E. S. Thomas). One of these, a male, at Newport, was taken with the yellow-jacket (*Vespa maculifrons*) as prey.

The Development of Genetic Characters.

This is one of the most valuable and important biological books of recent years. Recognizing the opposition of the fundamental concepts of genetics and those of experimental embryology in regard to the nature and development of the organism, the author attempts a reconciliation of these views. The facts of experimental embryology are clearly and logically set forth, and their contribution to the development of adult characteristics carefully evaluated. It is essential that all zoologists have access to a copy of this clear analysis of developmental problems.—L. H. S.

Experimental Analysis of Development, by B. Dürken; translated by H. G. and A. M. Newth. 288 pp. New York, W. W. Norton & Co., 1932.

NOTES ON A COLLECTION OF MYXOMYCETES FROM SOUTHEASTERN MICHIGAN.*

Floyd B. Chapman,
Ohio State University.

During the autumn of 1932, Mr. Clarence E. Taft, of the Department of Botany, Ohio State University, made a trip through southeastern Michigan, visiting portions of Macomb and Lapeer Counties. Although interested primarily in the collection of algae, he was able to secure nearly a hundred specimens of Myxomycetes or slime molds. Since then it has been the writer's privilege to work over the collection, and this paper is the result. So far as the writer can ascertain, nothing has previously been published on the Myxomycetes of this section of Michigan.

The writer is indebted to Mr. Taft for the large number of specimens, and to Dr. W. G. Stover and Dr. G. W. Blaydes for helpful advice and criticism. Professor T. H. Macbride's "North American Slime Molds" has been followed throughout.

1. **Ceratiomyxa fruticulosa** (Muell.) Macbr. Collected once, in woods north of Noland Lake, Macomb County, Growing on rotted maple wood. Rather common everywhere, according to Mr. Taft's notes.

2. **Fuligo septica** (Linn.) Gmel. This common species was found several times in a woods north of Noland Lake. In most cases the aethalia had been reduced to tatters by weathering. The form *ovata*, with yellowish foamy crust, was the form most frequently collected. On oak.

3. **Didymium melanospermum** (Pers.) Macbr. This beautiful species, with snow white sporangia and short black stalks, was collected once from oak in a woods north of Noland Lake.

4. **Diderma floriforme** (Bull.) Pers. This species, common in the Central States, was found on well decayed oak, in the woods north of Noland Lake. When collected, the sporangia were "closed," but after a few hours, began to burst open, giving to them the customary flower-like appearance.

5. **Stemonitis fusca** (Roth.) Rost. The dusky sporangia of this species were found a number of times in Hamilton's woods, 4 miles northwest of Romeo, Macomb County. On wood of large-toothed aspen.

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*Papers from the Department of Botany, Ohio State University, No. 321.

6. **Stemonitis virginiensis** Rex. This is believed to be the fourth record for the species in North America. It was collected once from aspen, in Hamilton's woods, northwest of Romeo.

7. **Stemonitis splendens** Rost. Rather common on oak and maple in Lapeer County, 8 miles northwest of Romeo.

8. **Stemonitis smithii** Macbr. The tall, slender, cinnamon-brown sporangia were collected twice from aspen, in Hamilton's woods, 4 miles northwest of Romeo. The sporangia measure up to 7 mm. in height.

9. **Stemonitis herbatica** Peck. A large number of sporangia were found on oak, northwest of Romeo. These specimens are very dfferent from the usual *S. herbatica*. According to Dr. G. W. Martin, of the State University of Iowa, they have been parasitized by a species of *Hyphomyces*. The parasitic fungus completely changes the appearance of the sporangia, causing them to take on a dull black color. Upon examination the spores and capillitium are found to be compacted into a dense mass. This *Hyphomyces* must occur rather generally on *S. herbatica*, as the writer also possesses several parasitized specimens from Ohio.

10. **Cribraria aurantiaca** Schrader. Collected twice from oak in Lapeer County, 8 miles northwest of Romeo.

11. **Lycogala epidendrum** (Buxb.) Fries. This species is common on many kinds of deciduous trees in southeastern Michigan. Specimens were taken from oak in the Harris woods, northwest of Romeo, and from oak and maple in Lapeer County, 8 miles northwest of Romeo.

12. **Arcyria incarnata** Persoon. Rather common on oak in both Macomb and Lapeer Counties. Specimens were collected in a woods north of Noland Lake, in the Harris woods, 3 miles northwest of Romeo, and again in Lapeer County, 8 miles northwest of Romeo. The sporangia are very irregular in shape, departing from the usual cylindrical form. They are weak and procumbent, cling together, and are frequently fused. However, the general color of the sporangia and the characteristics of the capillitium, spores, and stalk serve to place these specimens under *A. incarnata*, Pers.

13. **Arcyria denudata** (Linn.) Sheldon. Undoubtedly the most abundant slime mold of southeastern Michigan. It is to be found everywhere on many kinds of wood. Specimens were found on elm and maple in woods northwest of Romeo, another woods north of Noland Lake, and again in southern Lapeer County. The species also occurred on yellow birch in a cedar swamp 2 miles west of Romeo, on white oak in a forest southwest of Romeo, and in another woods 4 miles southeast of Romeo.

14. **Hemitrichia vesparium** (Batsch.) Macbr. Very common on maple, oak, birch, and other deciduous trees. Sporangia in all stages of formation—the mature plasmodium, fully formed sporangia, and the empty sporangia which resemble miniature "wasp nests," were found. The species was collected from woods northwest and southwest of Romeo, and from southern Lapeer County.

15. **Hemitrichia clavata** (Pers.) Rost. Common to abundant in most of Macomb and Lapeer Counties. On many kinds of wood: oak, aspen, birch, and maple. Collections are from northwest and southwest of Romeo, and southern Lapeer County. Both newly formed and aged sporangia were found.

16. **Hemitrichia stipitata** (Mass.) Macbr. Collected twice; northwest and southwest of Romeo. On aspen and maple. The presence of a complete capillitial net without free ends serves to distinguish this species from *H. clavata*.

17. **Trichia contorta** (Ditm.) Rost. Listed by Macbride as "rare" in North America. A large number of sporangia were collected from a decayed aspen log, lying partially submerged in a pond. Hamilton's woods, 4 miles northwest of Romeo.

18. **Trichia scabra** Rost. Collected once from oak in Harris woods, northwest of Romeo.

19. **Trichia persimilis** Karst. Found once on white oak in woods northwest of Romeo.

20. **Trichia favoginea** (Batsch.) Pers. This beautiful species was taken from oak, northwest of Romeo.

21. **Oligonema flavidum** (Peck.) Mass. On aspen, in Hamilton's woods, northwest of Romeo.

22. **Oligonema nitens** (Lib.) Rost. Taken once in an oak-maple forest southwest of Romeo.

Many of the Myxomycetes listed above are typical autumn species, notably the *Trichias*, *Oligonema flavidum* and *O. nitens*, *Arcyria incarnata*, and *Diderma floriforme*.

On the basis of number of times collected, the most common Myxomycetes of southeastern Michigan would seem to be, in the order named: *Arcyria denudata*, *Hemitrichia vesparium*, *Hemitrichia clavata*, *Lycogala epidendrum*, *Fuligo septica*, *Arcyria incarnata*, and *Ceratiomyxa fruticulosa*.

Of the twenty-two species mentioned, about four or five are particularly noteworthy. *Didymium melanospermum* has seldom been collected in the Central States. This is true also of *Stemonitis virginiensis*, *Stemonitis smithii*, *Cribraria aurantiaca*, and *Trichia contorta*. The writer feels sure that the rich forests of Michigan will ultimately yield many times the number of species listed in this paper.

FLORA IN THE ROOF OF THE UPPER FREEPORT COAL AT CALLAHAN'S MINE, TEEGARDEN, OHIO.

WILLARD BERRY.

Last spring several graduate students at Ohio State University collected several good specimens of plant fossils from the roof of Callahan's Mine, one mile north-west of Teegarden, Columbiana County, Ohio. These fossils were turned over to me and at my request the students revisited the Mine and in November one of the men, Mr. Sturgen, collected over 500 pounds of material. It is from this collection that the determinations have been made. As might be expected this method of collecting made for much duplication of forms but is compensated for in the abundance of material.

The coal mined at Callahan's Mine is the Upper Freeport which is at the top of the Allegheny series in the Upper Carboniferous or Pennsylvanian of the Paleozoic. The roof shale and the matrix of the impressions is a gray, slightly sandy, poorly bedded clay shale. There are small slickened blocks in some parts. In some instances there is considerable evidence of movement in the shale before complete compacting if we are to accept the irregular bending and curling of the plants. This curling could not be interpreted as curling due to dried material being inundated as there is no evidence of land conditions in the sediments; they appear to be water laid deposits. Also what bedding there is, is bent with the fossils. This condition was probably caused by eddies, or scour, or even something like tide riffs.

The flora as studied does not lend itself to correlation with other Upper Freeport horizons due to the lack of floral lists of this horizon. I expect to continue the study of this horizon and in time make a complete report on the Upper Freeport plants for the entire area in Ohio, in which report I will include illustrations of the plants.

In all there are at least 26 species, all previously reported from the Allegheny, comprising 7 genera and 5 families.

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*Read before the Ohio Academy of Science, April 14, 1933.

The tentative list is as follows:

Pteridophyta.

Ficales.

Triphyllopteridae.

Pseudopecopteris (?) cf. *obtusiloba* (Brongn.). Lx. Rare.

Pecopterideae.

Pecopteris dentata Brongn.....Common.
P. pseudovestita D. White.....Common.
P. vestita Lx. (not previously reported from the upper Allegheny).....Common.
P. arborenscens Brongn.....Fairly common.

Megalopterideae.

Neuropteris cf. *trichomanoides* Brongn.....Rare.
N. fimbriata Lx.....Rare.
N. auriculata Brongn.....Fairly common.
N. inflata Lx.....Fairly common.
N. Collinsii Lx.....Fairly common.
N. Scheuchzeri Hoffm. (*N. hirsuta* Lx.), most abundant fossil.
N. Rogersi Lx.....Fairly common.
N. sp. A.....Common.
N. sp. B.....Fairly common.

Sphenophyllates.

Sphenophylleae.

Sphenophyllum cuneifolium (Stb.) Zeill.....Rare.
S. majus Brongn.....Rare.

Lycopodiales.

Lepidondendreae.

Foliage.

Lepidodendron Brittsii Lx.....Rare.
L. lanceolatum Lx.....Rare.
L. rigens Lx.....Not rare.
(Probably more abundant as small fragments.)

Stems.

L. sp. A.....Rare.
L. sp. B.....Rare.
Lepidostrobus variabilis L. & H. (may represent several sp.).....Not rare.
Lepidophyllum lanceolatum Brongn.....Abundant.
L. majus Brongn.....Rare.
L. ovatifolius Lx.....Common.
L. sp.....Rare.

THE GENUS AGELLUS, GEN. NOV.

(Homoptera, Cicadellidae.)

DWIGHT M. DeLONG AND RALPH H. DAVIDSON,
Ohio State University.

In a recent number of the Journal of Science, January, 1933, the writers discussed the genus *Eugnathodus* (p. 55). A new name was suggested and description offered for the species which Baker apparently had in mind when he described the Genus *Eugnathodus*. At that time it was thought desirable to let the genus name stand if possible to prevent confusion in literature. But further study and consideration has revealed the fact that according to opinions 14 and 65 of the international code of Zoological Nomenclature, *E. abdominalis* V. D., must remain the type of the genus Eugnathodus since definite specimens were not designated although undoubtedly used.* *Eugnathodus* Baker consequently must be made a synonym of *Balclutha* Kirk and the name *Agellus* is here proposed for the genus previously designated *Eugnathodus* and which was described briefly in the paper cited above.

It is closely allied to *Balclutha*, but differs in the following respects: Vertex more broadly rounded and scarcely produced before the anterior margins of the eyes and anterior and posterior margins almost parallel, head slightly broader than pronotum, lateral posterior angles of pronotum not wider than vertex. General venation as in *Balclutha* with inner sector of elytra not forked, two ante-apical cells being produced. Oedagus of internal genitalia with dorsal, basal, protruding processes. In *Balclutha* the basal portion is enlarged and may extend dorsally but without finger processes.

Type of genus *Agellus neglecta* DeL. and Dav.

*This has recently been verified by P. W. Oman, Taxonomic Division, U. S. Bureau of Entomology, National Museum.

BOOK NOTICES.

Modern Alchemy.

There is a certain sentimental, yet pardonable, pride which we all feel in the family succession in the stage, law, business and even in science. This father and son joint contribution is something in which we may justly feel pride. The book is a review of modern developments in the field of chemistry. While a fundamental knowledge of chemistry is essential for the thorough understanding and appreciation of the book in its entirety, still, the average lay reader will find many enjoyable passages, and with a willingness to accept certain statements without going into the reasons for them should be able to appreciate the major portion of the book. A "popular" book in a scientific field must of necessity be either too complex or too elementary for many readers. The authors have attempted to follow an intermediate path which should appeal to both the professional scientist and the general reader. The book deals principally with the modern theoretical, rather than industrial, developments. Particular emphasis is placed on atomic structure and synthetic medicinals. A certain amount of emphasis is placed on the development and production of ideas and research from the University of Illinois, where the senior author was Director of the Chemical Laboratories for nearly a quarter of a century.

WALLACE R. BRODE.

Modern Alchemy, by W. A. NOYES AND W. A. NOYES, JR., 205 pp. Springfield, Charles C. Thomas, 1932.

The Triumph of Chemistry.

This is a popular book on a general theme of the importance of economic planning in chemistry. While the author discusses the rise and growth of chemistry in a historical sequence, he also takes numerous occasions to point out the influence of good and poor economic planning and to discuss the influence of the chemical industry on our present economic situations with regard to high tariff, farm relief, railroads, etc. The book is well written and, with the exception of two short chapters which the author suggests for a possible omission, the non-technical reader as well as the scientist should find the book to be well worth reading.

WALLACE R. BRODE.

Chemistry Triumphant, by WILLIAM J. HALE. 150 pp. Baltimore, Williams and Wilkins, 1932. (One of the Century of Progress Series.)

Fossils.

Those who have found Zittell's Textbook of Paleontology valuable will welcome this new revised edition of the second volume. The first edition in English was published in 1902, since that time much has been discovered and we are indebted to Dr. Smith Woodward for its inclusion in this new edition. The new edition contains 181 more pages and 160 additional illustrations, retaining, however, the same type of presentation and illustration that was preferred by Zittell. The classification has been carefully revised and is in keeping with the modern ideas on vertebrates. This volume covers from the earliest fish up to and including the birds.

W. BERRY.

Textbook of Paleontology (Zittell), translated by EASTMAN, revised by SIR ARTHUR S. WOODWARD. Vol. II, 464 pp. New York, The Macmillan Co., 1932.

Snakes and Kinkajous.

The well-known naturalist of the Bronx Park Zoo has added another to his books of adventure. Much of an informative nature is here, and many thrills and not a few laughs await the reader. The strictly scientific reader must close his eyes to many a teleological statement, such as, "A copperhead among dead leaves is a remarkable illustration of protective resemblance. The snake knows this, hence the quiet attitude of most copperheads and their lack of inclination to strike or bite, unless touched or stepped on," but there can be no questioning Dr. Ditmar's ability as a naturalist, nor his intense enthusiasm. The reader will share the thrills and enthusiasm to the fullest extent, and will emerge wiser in the ways of serpents and their poisons, not to mention other odd animals.

L. H. S.

Thrills of a Naturalist's Quest, by Raymond Ditmars. 268 pp. and 45 illustrations. New York, The Macmillan Co., 1932. $3.50.

Crystals.

This book, while designed primarily for students of petrology, will be of service to students of chemistry and physics and especially to ceramic and metallurgical engineers who need to have the fundamentals of crystallography clearly set forth in a readily understandable fashion.

The text contains the conventional material as to the nature, classification and physical properties of crystals, together with two chapters, one on the optical properties of minerals, and one on the methods of investigation of optical properties of bodies in general.

As stated in the preface the author has touched rather lightly the fundamental topic of crystal structure and unit lattice as being a topic beyond the ability and training of the average student of geology. It is confidently predicted that the next generation of geology students will insist that these ropics be amplified in future text-books of this sort.

The book is attractively edited, a thing that is true of anything the Cambridge Press turns out. It should find a ready sale among elementary students of the physical sciences, especially of mineralogy and geology.

F. C. Blake.

Form and Properties of Crystals, by A. B. Dale. 186 pp. New York, The Macmillan Co., 1933, (Cambridge, The University Press), $1.60.

Dissection of the Cat.

This manual of practical directions for the dissection of the cat and the study of its anatomy represents a revision of the directions for dissection which were formerly included in Reighard and Jennings' **Anatomy of the Cat,** but here published as a separate manual. It includes a discussion of essential literature on this subject, the preparation and use of specimens, and directions for laboratory dissection by the "System Plan," taken from the former volume. These have been revised by Dr. Elliott, of Ohio University, who has also added his directions for dissection by the "Regional Plan," traditionally used by teachers of human anatomy. Both methods are thus made available to the student within the compass of a single manual of convenient size for laboratory use. Many page references are given to descriptions of structures in Reighard and Jennings' Anatomy of the Cat which this manual is written to accompany. A useful chart, summarizing the nerve supply to important muscles of the body, and a large diagram of the nervous system is given in the appendix. This is recommended for its concise arrangement, and its ready adaptability to laboratory work.

John W. Price.

Dissection of the Cat, by Jacob Reighard and H. S. Jennings. Revised, with the addition of A Manual of Regional Dissection, by Rush Elliott, vi + 106 pp., New York, Henry Holt and Co., 1932.

The Foraminifera.

After some years of consideration the author has published his ideas on the classification of the Foraminifera. Of the roughly 1,100 generic names that have been published, he considers 542 of them to be valid. The rest of them are either brought into the "valid genera" or are discarded as being invalid, unrecognizable, **Nomina nuda,** or else as not being foraminifera at all. Throughout the entire classification the rules of Zoological Nomenclature are rigidly followed, which procedure, although excellent, leads to the finding of some forgotten names. In this classification the author recognizes 35 families as against 10 by M. S. Schultz (1854), 21 by A. E. Reuss (1861), 10 by H. B. Brady (1884), and 45 by Cushman (1928). The present classification in use, is mainly Cushman's in this country, and Brady's in Europe, with some using Cushman's. The genera are all illustrated and in most cases are after the type figure. The illustrations are all line cuts and quite clear, though as must be expected in a work of this kind, limited in number for each genus. There is a good glossary and index.

W. Berry.

A Manual of the Foraminifera, by J. J. Galloway. 481 pp. Bloomington, Indiana, The Principia Press, 1933.

Atoms.

The University of Pittsburgh Physics Staff have recently given us a rather delightful book, the purpose of which is to acquaint the beginner in natural science with much of that which is occupying the minds of present day physicists.

The book begins with a short introduction which in reality is a summary of the status of physics at the beginning of the century. This is followed by three chapters devoted to the corpuscular nature of matter, electricity, and radiation. The middle portion, comprising seven chapters may be said to be devoted to atomic and molecular structure, beginning with a survey of spectroscopic methods, containing many clear and instructive plates and diagrams. The interpretation of line spectra and x-ray spectra in terms of Bohr models and subsequent vector models is treated at some length and is followed by a discussion of crystal structure as revealed by x-ray experiments. The subject matter, **waves and corpuscles,** is obviously difficult to treat in so brief a space and in so elementary a fashion and to the writer it appears that this chapter lacks some of the desired clarity. It seems that a very elementary problem (say that of the simple rotator, discussed but not actually carried out in Chapter XI) might have been inserted as an example of Schrodinger's theory. Chapter XI is devoted to the topic of molecular structure and molecular spectra, and gives to the layman quite a vivid and clear representation of that field of endeavor. Here again, it is felt that the pseudo quantum mechanical treatment of the rotator as given is unsatisfactory and that a more compete treatment as earlier suggested is much to be preferred.

The remaining chapters are devoted to nuclear physics, relativity, astrophysics, and related topics, closing with five very helpful and valuable appendeces. A detail which ought not to go without commendation is the list of problems at the end of each chapter. The goal toward which the authors strive; namely, to place in the hands of the layman, reliable accounts of the teachings of physical science, is a most difficult one, and the writer feels that on the whole the authors are to be congratulated on their success. H. H. Nielsen.

Atomic Physics, by members of the Physics Staff of the University of Pittsburgh. v + 335 pp. New York. John Wiley and Sons, 1933. $3.50.

Disease and Insects.

Here is a practical and readable book written for students interested in medical entomology and public health service. The author is a public health surgeon. The first two-thirds of the book are devoted to the various groups of arthropods, their anatomy, taxonomy, life history, and control. There are many

workable keys, some good diagrammatic figures, and a few notes on technique. A discussion of a dozen or so diseases carried by arthropods follows, with especial reference to the causative agents, modes of transmission, epidemiology, and methods of control. It is a concise and authentic text, and although it lacks an extensive bibliography, should prove an excellent addition to the scientist's library.

J. HAUB.

Insects and Disease of Man, by Carroll Fox. xii+349 pp. Philadelphia, P. Blakiston's Son & Co.

A Billion Years.

This addition to the Century of Progress Series tells the story of geology in terms that are readily understood by the non-technical reader, but which will be equally appreciated by the scientist. The geologic history of the earth is first developed, followed by the record of living things. The story of the glaciers is interestingly told. A thoughtful discussion of the future from the standpoint of practical geology concludes the book.—L. H. S.

The Story of a Billion Years, by W. O. Hotchkiss. x + 137 pp. Baltimore, The Williams and Wilkins Co., 1933.

Earth Lore.

Professor Shand has written an extremely useful book for those who are interested in geology, but who lack the technical vocabulary to enjoy the laborious reading of texts. Geology is here considered under the following heads: Seeing things to scale, the face of the earth, earth sculpture, the sea floor, the book of the rocks, the creation saga, the age of the earth, what lies beneath the crust?, deeper and deeper, chimneys in the crust, the problem of mountains, rifts and ramps, how is the crust held up?, drifting continents.

Both the author and the publisher are to be congratulated on this book. It is very readable and well executed.—W. BERRY.

Earth Lore. Geology without Jargon, by S. T. Shand. 134 pp. London, Thomas Murby and Co., 1933.

Geological Vocabulary.

This little book should fill the long felt need of a vocabulary of French to English for the geologist. It is not burdened with the more common words but abounds with those words that are so hard to find in the common literary dictionaries. It is expected that it will find considerable use, especially among the student, and the more experienced persons of geology.—W. BERRY.

A French-English Vocabulary in Geology and Physical Geography, by G. M. Davies. 140 pp. London, Thomas Murby and Co., 1932.